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OF HISTORY AND ITS METHOD

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I
Conceptions of History

WHAT IS HISTORY?

History has been variously defined. Differing conceptions of history reflect the variability of human beings and their cultures. To pre-literate man, history is remembered tradition; in literate societies it may come to be thought of as the written record of things past. To the politically conscious, history is past politics, and politics is history in the making. To philosophers, history is philosophy teaching by example. None of these notions is sufficiently inclusive: things change and have histories as do men. Were there no change, there would be no history. History, the Book of Changes, is the totality of what has transpired: environment, and what it has done to man; man, and what he has done and sought to do with himself and his environment. Whether this totality be known, or knowable, and how precisely, are mooted matters; but historical study aims at the fullest possible knowledge of the past.

Human history, itself, has a long history.[1] It falls into several patterns, beginning with the unconscious record and culminating in the conscious, critical study of all discoverable records. Apart from the unpremeditated story man left in his earliest tools and other remains, three other broad types of more or less conscious testimony to his past may be distinguished: a pre-literate registry of time and events, kept by knots in cords, notches on sticks, scalps in a belt, heads piled up, feathers in a headband, and similar devices; remembered tradition, preserved in tales told and songs chanted — the poetry of life's morning, treasured in skaldic verse, *Nibelungenlieder*, the Mahabharata, Homeric hymns; finally, a conscious, more or less methodic effort to reconstruct and preserve in written or pictured form a portrait of the past — a reconstruction aiming, with varying emphasis, at entertainment, inspiration, and serious instruction. The line between poetry as history and history as art and entertainment is naturally tenuous. So, too, was the boundary once drawn 'twixt pre-history and history, which relegated to the former all testimony of artifacts, pre-literate chronicles, and oral tradition, and labeled as history only what was established and written down.

[1] See, for example, Barnes, H. E., *A History of Historical Writing*; Thompson, J. W., and Holm, B. J., *A History of Historical Writing*. For further bibliographical data for this and subsequent references consult bibliography.

PHILOSOPHIES OF HISTORY

When the writing of history came to be a conscious, formal effort, philosophies of history arose. Mythology, as Schelling said, is primordial history. In mythology and theogony may be glimpsed man's earliest, poetic groping for a philosophy of history. Intellectual advancement brought a quest for a sounder formula. Of first-rate importance was the development of a naturalistic, rational theory of history among the Greeks. Systematic historians, professing a desire to discriminate between the reasonable and true and what is false, irrational and ridiculous, began progressively to dispense with previously accepted mythology. Hecataeus (550 B. C.) claimed truth as his goal, and discounted many Greek tales as ridiculous. In the mid-fifth century, Herodotus traveled extensively, seeking knowledge by direct inquiry for his portrayal on a broad canvas of the great conflict between Persian and Hellenic cultures. True it is, his love of tall tales links him, in some degree,

to poetical historians and entertainers; and he is by no means able to discount wholly the doings of the bright gods amongst men. But Herodotus' work, despite the elements of credulity and story-telling, marked a great advance in the writing of history.

Thucydides, in the late fifth century, continued the quest for truth in history with more success than his predecessors. Disdainfully throwing overboard the role of romancer and entertainer, he saw past history as a potential light for the future, and did much to advance the conception of history as a science. True history, he thought, in contrast to that which pleases the ear for a moment, should be a permanent gain, a joy forever. Relying on a cyclic theory of human affairs, and adhering to natural, rational causation, as opposed to supernatural, he believed that accurate, factual knowledge of what had happened should enable one to see what would in future come to pass again, the same or nearly so.[2]

Polybius (*c.* 201-*c.* 120 B. C.) far surpassed Thucydides in clarifying historical method. Above all ancient authorities he embodied the ideal of scientific history: he would know facts accurately, discern causes and consequences, and in light of this knowledge look into the future. The purpose of historical study is serious, essentially practical: true history, which deals with great affairs rather than petty ones, is the best corrective of human conduct, the best preparation for a life of political activity.[3] Polybius holds to a naturalistic, cyclic interpretation of the origin and development of society and government. Every constitution has in itself the seed of decay. Conceptions of goodness, justice, duty, courage, honor, and their opposites also, arise from natural causes.[4] Ascription of supernatural intervention, improbable and impossible, fills Polybius with repugnance. Such beliefs are childish, the sign of a blunt mind. He will excuse writers of such things in some degree, however, if thereby commoners' piety toward the gods may be increased.[5] But true history seeks to know the facts as to what was done and said, and the reasons therefor. Nothing should be more sought after than the first causes of events and their consequences. Facts may be interesting, but knowing the cause behind them makes history fruitful. Utility is the goal.[6]

The usefulness of history depends upon the historian's fearless and objective quest for truth. Truth is of higher worth than anything else; an historian, if he values other matters — rewards, personal relations, patriotism, rhetorical display — more highly than truth, is unworthy of confidence.[7] As historian, one must judge friend and foe impartially. Sound, reliable knowledge is to be gained from first-hand study of authentic documents, by visitation of places, and interrogation of witnesses. Knowledge of geography, of military and civil affairs is indispensable to the historian.[8] Polybius emphasizes the necessity of judging any author's credibility, so that error and truth may not stand on the same footing. Some writers are no more reliable than barber-shop gossip.[9] If one finds one or two deliberate falsifications in a work, its reliability in general is thereafter under suspicion.[10] An author should never be judged trustworthy because of his title or reputation, but by the conformity of his statements with actual facts.[11] Polybius knew much of his own subject at first-hand. Though a Greek, he had lived in Italy 16 years; he tutored Aemilius' sons, hunted with them, went on campaigns, and thus came to know public and private life.

Wholeness of theme, in Polybius' judgment, is a sound principle of selection. A whole, connected history, bound by one thread, is better than many, partial histories that deal with individual, isolated events. In setting about writing, a preview of the whole, before addressing one's self to the parts, is an aid to the mind.[12] Clarity and simplicity in writing and completeness of treatment of the chosen theme are the Polybian ideal, rather than rhetorical style and ostentatious learning.[13]

When the Hebrew-Christian tradition flowed into the current of Graeco-Roman thought, belief in the supernatural intervention of pagan deities — in so far as it had survived, despite the progressive acceptance of natural, human, rational causation — was supplanted by the thesis of "God in History." Augustine's *City of God* set the pattern of this philosophy

[2] Thucydides: *The History of the Peloponnesian War*, I, 21-22. (Trans. by H. Dale)
[3] *The Histories*, I, 1, 35. (Trans. by W. R. Paton)
[4] *Ibid.*, VI, 5-10.
[5] *Ibid.*, XVI, 12; XXXVI, 17.
[6] *Ibid.*, III, 4, 7, 31-32; XII, 25b.
[7] *Ibid.*, I, 14; XVI, 14; XXXVIII, 4-6.
[8] *Ibid.*, III, 4, 33; XII, 25e, 28; XVI, 20.
[9] *Ibid.*, II, 56; III, 20.
[10] *Ibid.*, XII, 25a.
[11] *Ibid.*, III, 9.
[12] *Ibid.*, I, 4; III, 1, 32.
[13] *Ibid.*, XVI, 17; XXIX, 12.

of history — the embodiment of God's unchanging will.[14] Since then, philosophers with a theological background and bias have expressed the God-in-history thesis in various forms. Schelling saw history as an epic, "composed in the mind of God." Christianity represents the "revelation of God in history." Jesus is the key to universal history. Hegel's rationalism — his conviction that "the history of the world . . . presents us with a rational process" —[15] is a thinly disguised secular formulation of the old theological thesis. A recent writer, Berdyaev,[16] considers the Jews the first to have a true sense of the historical, and Christianity "the greatest dynamic force." "This dynamic and historical character is peculiar to Christianity, which alone attributed a general and ultimate goal to mankind." It alone, Berdyaev believes, "made possible both positive science and technique." Marx, himself, is faithful to the traditional, Jewish Messianic complex, though he assigns the Messianic role to a chosen class rather than to an individual or a people.

Diametrically opposed to the supernaturalistic, God-in-history thesis and the absolute idealism of Hegel is the materialistic conception of history. Though formulated by Marx and Engels in the mid-nineteenth century, this modern, uncompromising materialistic interpretation of history is by no means a wholly novel realization of the influence of nature and economic affairs upon human life. Thinkers of antiquity came close to some of the same conclusions, though not so systematically and dogmatically. Hippocrates showed the relation between human beings and habitat. In general, he thought, the nature of a country affected physical and other traits of its population.[17] The far-reaching influence of geography on empire was understood by Strabo,[18] Polybius, and other historians. Lucretius' great poem, *De Rerum Natura,* interpreted the whole of existence in a thoroughgoing materialistic fashion. Wars, he knew as well as Marx, had been caused by quest for economic gain.[19]

Modern naturalistic tendencies, science, and technology, which so rapidly altered economic life after the seventeenth century, gave an impetus to a materialistic interpretation of life which swept round the world. Marx, the scholar, formulated systematically a philosophy of history which, in some form or other, had been gaining adherents in many quarters; but Marx, tribune of the proletarians and preacher of revolution, found fewer followers. Marxian interpretation of history was a derivative, and an inversion, of Hegelian thought. Though deeply influenced by Hegel, and in some respects an enthusiastic follower, Marx considered the "idea" only a reflection of the material world in human understanding; Hegel had turned the universe upside down and made the "idea" the demiurge of the real world. According to Marx's inverted Hegelianism, the most important thing was "to lay bare the economic law of motion of modern society."[20] Civil law itself is the embodiment of the interests and will of the property-owning class.[21]

The economic interpretation of history — minus the dogmatism of Marx and his advocacy of revolution — made rapid headway, partly as a balance to previous, opposite extremes, partly because of the growing recognition that, regardless of what other factors may have been operative, economic forces were, in any case, fundamentally important in man's life. Rogers, though not a disciple of Marx, faithfully and laboriously showed the profound effect of economic affairs on English political and social history, but lamented that, to his time, the history of certain periods had been written and rewritten in entire neglect of economic matters. Even Freeman had failed to use the valuable economic data recorded in the Domesday Book.[22] Two able French historians recognized (1897) that "Every evolution has for its cause a change in the material conditions or in the habits of certain men."[23] The God-in-history thesis, in its original form, they believed, had fallen into general neglect, though it appeared in philosophical disguise.

Apart from his professed disciples, the tendency has been to regard dialectical materialism as much less scientific than Marx held it to be. The chief weaknesses as a science lay, doubtless, in the *à priori,* teleological character of the thesis — which was no more an induction from all history than was Hegel's opposite

[14] *The City of God,* XI, 1; XII, 14, *pass.* (Trans. by J. Healey); Bunsen, C. C. J.: *God in History.* (Trans. by S. Winkworth)

[15] *The Philosophy of History,* 9 *f.* (Trans. by J. Sibree)

[16] *The Meaning of History,* 28, 36, 89, 117, 124, *pass.*

[17] "Airs Waters Places," *Hippocrates,* I, 137. (Trans. by W. H. S. Jones and E. T. Withington)

[18] *Geography,* VI, 4, 1. (Trans. by H. L. Jones)

[19] *De Rerum Natura,* V, 1435. (Trans. by W. H. D. Rouse)

[20] *Capital,* I, 14, 25. (Trans. by S. Moore, E. Aveling, and E. Untermann); Bukharin, N.: *Historical Materialism.*

[21] Marx, K., and Engels, F.: *Manifesto of the Communist Party,* 27. (Trans. by S. Moore, ed. by F. Engels)

[22] Rogers, J. E. T.: *The Economic Interpretation of History,* 2 *f.*; see, too, W. J. Ashley: *Surveys Historic and Economic.*

[23] Langlois, C. F., and Seignobos, C.: *Introduction to the Study of History,* 294. (Trans. by G. G. Berry)

theory — and its Messianic rôle as an inspiration and guide to proletarian revolution. Disturbing, too, to a scientific mind, is the Marxian readiness to see economic forces as sole cause. Nordau recognizes that "entirely outside" man's will, natural environment has had an influence on individual and group destinies that outranks everything else. When nature sets man's table, he remains at the lowest level of culture. But there is no good reason for making an antithesis between man and natural forces.[24] Sée finds "a large element of truth" in the doctrine of materialistic causation. Economic forces, he thinks, are less subject to chance than others; nevertheless, economic determinism is not a law which will permit us to foretell the future.[25]

Between the poles of supernaturalism and materialism stands the humanistic interpretation of history. This philosophy, emphasizing the rôle of man, is variously expressed; it exhibits in some hands a religious, theological leaning; in others, a secular, social bent; again, a mingling of the two. Put in Hegelian fashion, supernaturalism is the thesis, materialism the antithesis, and humanism the synthesis. Carlyle, in *Heroes and Hero-Worship*, rebels against the view "that this world is a steam-engine." "We cannot do without Great Men." *Past and Present* shows him keenly aware of the evil in industrial society: England, full of wealth, is full of poverty, suffering from overproduction! Marx and Carlyle crusade against this evil: For one, the cause is material; for the other, moral.

Comte's *Positive Philosophy*[26] viewed all history as dominated by the human spirit. Froude maintained that cause and effect could not be reckoned upon in human history, due to the freedom of will.[27] Herder held to the humanistic view, and conceived of reason in human affairs as a goal dictated by human nature.[28] Mathews, a century later, striving to avoid the miraculous control of events by God, as Augustine expounded it, and also the determinism of economic and geographic conditions, seems to be groping for much the same idea: namely, that social development is moving "from occasion and control by impersonal forces and economic wants to the spiritual freedom which lies in inner self-direction towards spiritual ends." This seems to have much in common with Hegelian rationalism and *Weltgeist*. Mathews entertained also a considerable degree of optimism regarding spiritual freedom that should follow the first world war, which was to "make the world safe for democracy" and usher in "a more complete embodiment of the ideals of the Christian religion."[29]

Historians and philosophers, who have produced such a volume of literature on philosophies of history, doubtless reflect the all but universal human desire to read the future. But when one has surveyed the various conflicting theses, one may feel inclined, whether justifiably or no, to lament with Faust:

Have now, alas, philosophy . . .
And, sadly too, theology
Conned thoroughly with hot endeavor;
Yet stand I here, poor ignorant fool,
And am as clever as of yore!

Is there no value in philosophies of history? Are they one and all as meaningless as Hegel's detractors held his historical logic to be? Should one see only humor in his serious formula, just as one finds it in the oft-told student application of it: "thirst is thesis; beer, antithesis; under the table, synthesis!" It would seem that one should not be ignorant of what has bulked so large and influentially in the domain wherein he proposes to labor. Perhaps it may be put thus: one should be *occupied* with philosophies of history, but not *pre-occupied* with one of them. Then, one might intelligently judge their degree of truth, if any be in them; and, in any case, be fully sensitized to discover readily the bias of any author.

History, Art or Science

Whether history is art or science is an old, old question. Clio was one of the ancient muses. History was first art, entertainment, inspiration; her devotees relied on rhetorical devices to please the ear and stir the emotions. Thucydides and Polybius, though by no means wholly free from old patterns, diverged from the traditional conception and sought to place fact above fancy, instruction above inspiration, plain statement above rhetoric. Cicero discussed the rise of fine style among Greek historians. As for himself, though his speeches and letters show what pains he spent to get the

[24] Nordau, M.: *The Interpretation of History*, 16 *ff.*, 147. (Trans. by M. A. Hamilton)
[25] Sée, H.: *The Economic Interpretation of History*, 113, 121. (Trans. by M. M. Knight)
[26] Comte, A.: *Positive Philosophy*, II, 299 *f.* (Trans. by H. Martineau)
[27] Froude, J. A.: *Short Studies on Great Subjects*, I, 10 *f.*
[28] *Outlines of a Philosophy of the History of Man*, I, 125-188. (Trans. by T. Churchill)
[29] Mathews, S.: *The Spiritual Interpretation of History*, viii, 68.

right word, or phrase, he held that the object of the historian must be to tell the whole truth.[80] Tacitus, too, would hold truth inviolate, speaking "of no man with either hate or favour."[81]

With the decline of the age of reason and the advent of the age of faith, however, history as a serious quest for truth subsided. Critical doubt was long at low ebb; credulity flourished. Dante, one of the ablest minds of his age, could speak of "Livy that erreth not." Histories of the Renaissance period scarcely improved on the manner and method of the ancients.

Not till the seventeenth and eighteenth centuries was serious doubt expressed about the history of Rome, as told by the ancients. In the nineteenth century, however, Beaufort, Niebuhr, Mommsen and others carried the work of criticism so far, a recent writer asserts, that "absolutely nothing is left of the tradition save its ruins."[82] The new skeptical, scientific tendency doubtless led to extremes: Macaulay asserted roundly that "no historian has shown so complete an indifference to truth" as has Livy.[83] Today there is a somewhat more moderate judgment of the ancients.

The patterns of historical writing in the United States were similar. Before the nineteenth century, history as a science was unknown. Slowly at first, but rapidly after 1880, the scientific movement swept the country. Signs of reaction are now abundantly evident. Historical science in the United States reflected the influence of European, especially German, intellectual life. Ranke's seminar at Berlin, and those at Leipzig, Bonn, and elsewhere, became well known to American scholars. John Quincy Adams is said to have employed the seminar method at Harvard (1806), due to the influence of Von Maurer and Waitz, transmitted through Henry Maine and William Stubbs. Charles Kendall Adams introduced the German seminar at the University of Michigan in 1869. H. B. Adams used the method at Johns Hopkins University and at Smith College (1878) and publicized it in his *Methods of Historical Study*, and elsewhere. Emerton emphasized the view that history is entitled to a place as a science, because it has a "scientific method." The seminar's "mission" in America was to inculcate that method.[84]

Goldwin Smith expressed the view (1859-1861) that history could "never be a science," but recognized, somewhat equivocally, that it was "capable of being brought to perfection."[85] By the end of the nineteenth century, however, the scientific conception of history had attained a high, well-established status. History and its method were compared with geology, biology, astronomy, and older sciences. The greater and the lesser difficulties of the historian as scientist were carefully noted. Able scholars anticipated the time when no one would dare write unscientific history.[86] J. B. Bury[87] called history (1903) "simply a science, no less and no more." George Trevelyan, looking back some years later, realized that the scientific Potsdam Guards School of History had effected some improvements, but he regretted that they had driven out "literary" historians.[88] He insists that Clio winked an eye at the changing fashions. Did she know that they would soon change again?

Discussion of history as a science has turned consistently upon certain central matters, and has led to a large degree of agreement concerning them: scientific limitations of history; ascertainment of facts; sources; cause, effect, and prognosis; objectivity; truth versus style; and methodology. In general, it soon came to be understood that history is an "inverse" science; its events are not directly or precisely knowable, as are those of physical, experimental sciences; certainty is impossible, in many respects, but a high degree of probability can often be established.[89] To get at true facts, or probabilities, as precisely as possible by careful weighing of all the evidence, to reconstruct the human scene and judge its meaning, is the primary function of history. The ability to do this is the greatest an historian can hope to possess.[90] In fulfillment of this object, the quest first and last leads back to the best sources. Evidence from such sources may be treated scientifically; in so far as it is so treated, history is a science. Cause and effect relationships, however, and the prediction of outcome, after the manner of certain other sciences, have

[80] *De Oratore*, II, 15. (Trans. by E. W. Sutton and H. Rackham)
[81] *The Histories*, I, 1. (Trans. by G. G. Ramsay)
[82] Homo, L.: *Primitive Italy and the Beginnings of Roman Imperialism*, 2. (Trans. by V. G. Childe)
[83] Lawton, W. C.: *Introduction to Classical Latin Literature*, 181.
[84] Adams, H. B.: *Methods of Historical Study*, 87, 91, 93.
[85] *Lectures on the Study of History*, 29, 45.
[86] Langlois and Seignobos: *op. cit.*, vi.
[87] *Selected Essays*, 22. (Ed. by H. Temperley)
[88] *Clio, a Muse and Other Essays*, 4, 47.
[89] Crump, C. G.: *The Logic of History*, 7 *f.*
[90] Langlois and Seignobos: *op. cit.*, xii; Crump: *op. cit.*, 51 *f.*; Temperley, H.: *Research and Modern History*, 9.

been generally thought to elude the historian's method. In this again, however, the question of the precision and the scope of prediction enters. Though the study of trends has made great progress in the past generation, ambitious pretensions to reading of the future and the guidance of politics, which appealed to Thucydides, and to certain modern historians as well, are rarely found.

Objective, impartial history has been commonly regarded as an impossibility.[41] Subjective elements creep in willy-nilly. Like other scientists, however, historians know the value of cool, detached judgment. Objectivity is an ideal; impartiality is the "first duty" of the historian, says Crump. "The genuine seeker after truth and knowledge must approach facts without preconceived opinions about them," says Nordau.

In their effort to break with Clio's dubious past, the new historical scientists made something of a fetish of facts versus style. Artistry was neither necessary nor important. Brilliant writing had been the bane of history;[42] style had conferred immortality on authors. Scientists wanted no popular circle of readers, wished no immortality. Modestly and courageously, knowing that science advances day by day, they faced the fact that tomorrow would see their scholarly monographs replaced with new and better ones. The very literary excellence of certain French, English and American historians made them suspect in the eyes of scientists. Macaulay, Gibbon, Carlyle, Prescott, Thierry suffered eclipse. The sun of Gierke, Ranke, Waitz, Stubbs, Adams rose high. Some, it's true, sought harmony: "accuracy of matter" joined with "vigour and eloquence."[43] Trevelyan thought French historians had succeeded in combining German science and literary excellence, producing something "at once scholarly and delightful."

Why Study History?

Of what value is the study of history? As in every other study, it is obvious that value of history varies in proportion to the time and effort given to it; it is also contingent upon the individual equation of the student. Assessments of value fluctuate, too, according to different philosophies. Moreover, those who approach history as an art and those who regard it as a science will discern different values in it. In short, judgments of value are highly individualistic; they range all the way from the top to the bottom of the scale. It has been cynically remarked that one learns nothing from history, save that one learns nothing from history! If history were incapable of being anything more than "a child's box of letters, with which we can spell any word we please," as it seemed to Froude, one might indeed despair of profiting from it. A Sorbonne professor is credited with the dour remark that "the distinguishing feature of history is to be good for nothing." At the opposite extreme is the view of Confucius: "With a brass mirror you can adjust your hat; but with antiquity for a mirror you can predict the rise and fall of empires." So thought Thucydides. Bury, too, had high hopes of history: "research and the accumulated work of specialists may move the world."

Between these two extremes, everything and nothing, may there not be some common ground? Langlois and Seignobos considered it an illusion that history is the "teacher of life," that it gives practical help today; but they recognized that it aids in understanding the present by illuminating the past. Frederic Harrison observed that everyone, as soon as he is interested in anything, is of necessity interested in history. Nordau, while he discounts history as a means of general education — seeing that what is learned is so readily lost — notes that psychological and sociological need for knowledge of the past is almost universally recognized by societies and governments.

If history learned has been so speedily forgotten, seemingly *spurlos versenkt*, several factors may account for it. Whether it be general social history or the history of education, perhaps we have studied it too indiscriminately, whereas attention should be given to certain guiding principles (unity, continuity, balance) and the history of problems that really matter.[44] What an incubus, too, has been that old notion that anybody may be set to teaching, or even writing, history!

In respect to the history of education, I have elsewhere noted, it has suffered vastly from an understandable but false dichotomy: mental education versus physical. *"Educational history should hold to the principle of balance in the study of intellectual and physical aspects of man's education.* To concern ourselves almost wholly with intellectual aspects of education, as

[41] Nordau: *op. cit.*, 19; Temperley: *op. cit.*, 18; Jeudwine, J. W.: *The Manufacture of Historical Material*, 3; Berdyaev: *op. cit.*, 21 *f.*

[42] Harrison, F.: *The Meaning of History*, 8.

[43] Freeman, E. A.: *The Methods of Historical Study*, 104.

[44] National Society of College Teachers of Education, *Yearbook Number XXIX*, 1944, pp. 20-26.

the common practice has been, is to distort reality and mislead minds. By physical education, it must be noted, is meant not just formal practices, but the informal activities of work and play, and the systems of training for war. If both were studied together, a sounder view of physical education would be developed; and from a truer measure of the rôle played by physical education in social existence there would be necessarily a reëvaluation of the rôle of intellect which has apparently been much overrated. We have given much weight to the history of intellectualism in ancient Rome, and this was important; but Rome certainly educated many more millions of her people in the schools of the circus and arena, leading them to unlearn industry and to acquire the ways of idleness. An educational institution of 'higher learning' in the United States today that seats 10,000 in its classrooms will easily seat four to eight times that number in the stadium. The education of and for the stadium, whether in ancient or modern times, merits closer examination and comparison with other aspects of education."[45]

There has been a failure, also, to judge discriminatingly the rôle which history may properly be called upon to play in education. In keeping with the dominant trend in this practical-minded world, many have sought to make Clio serve immediate, utilitarian ends. They strive in vain. Hers is a long term utility, not immediate. Bury gave a sound definition of the goal of higher education: "the training of the mind to look at experience objectively, without immediate relation to one's own time and place." To such an end history is qualified to contribute.

The functions that historical study may legitimately be expected to perform, assuming adequate time and talent be given to it, have been discussed elsewhere.[46] A brief restatement of them will suffice. History is the telescope of social science, an instrument of many parts (auxiliary studies), constructed and perfected by many minds throughout the centuries and still being improved. By means of it the vast panorama of man's career is brought before our eyes, that we may analyze it and know it, often more thoroughly than contemporary men were able to do. If carefully, rationally, critically used, this instrument may be serviceable in orientation and guidance — not in the precise sense of reading the future, for history is no magician — aid in the discovery of principles of social growth and decay,[47] and enable us to construct a synthesis of man's endeavor. As an end result, the skeptical habit of mind, of which both scientist and citizen have ever the greatest need, should be vastly increased by a faithful, critical study of history, for it is a natural antidote for the "disease of credulity." General culture, inspiration, and a decent humility before the great contributions of other nations, which arise incidentally from the material and method of historical study, are by no means to be underestimated. These have been all but universally admitted and acclaimed, but probably not generally gained, due chiefly to faults of time, sequence, pedagogy.

II
The Method of History

Common Grounds of Scientific Effort: Ascertainment of Fact; a Common Method

On approaching the method of historical investigation it is well to note that history as a science is concerned in the first place with ascertaining facts as accurately as possible. Superstructures — reconstruction of the pattern of life, interpretation, cause and effect relationships, prediction of trends — must inevitably be worthless if the primary condition, the basis of facts, has not been met. This common ground, history shares with all sciences. Cicero had the matter in mind: "For nothing can be reduced into a science, unless he who understands the matters of which he would form a science, has previously gained such knowledge as to enable him to constitute a science out of subjects in which there has never yet been any science."[48] All present sciences, he continued,

[45] *Ibid.*, 22 *f.*; the author has sought to embody such a treatment of the physical and mental aspects of education in "Life and Education in Early Societies," to be published by The Macmillan Company, New York.

[46] Woody, T.: "Clio and the Teacher; or, The Place of History of Education in the Education of Teachers." *Sch. and Soc.* (Mar. 17, 1934) XXXIX, 321-330.

[47] Cheyney, E. P.: *Law in History and Other Essays*, 1-29.

[48] *On Oratory and Orators*, I, 41-42. (Trans. by J. S. Watson)

were formerly "unconnected," in a state of "dispersion." The quest of fact being common to all sciences, and the organizing agent — the human mind — likewise, the methods of all have a common basis, though differentiation in details arises from the varieties of sources and data with which they have to deal. As Huxley said, the principles of scientific method are the natural principles of the human mind, and "the method of scientific investigation" is "the same for all orders of facts and phenomena whatsoever."[49]

The Difficulty of Historical Research

The road to scientific truth is always hard. Darwin alludes to his study as "patiently accumulating and reflecting on all sorts of facts which could possibly have any bearing on it."[50] The method of history is no less difficult and laborious than that of other sciences; in some respects, it is even more so, for the historian cannot contrive to bring his materials into a laboratory, set up experiments, control conditions, push figures through comptometers, or rely on questionnaires.[51] The nature of the sources may compel him to spend years—

Letting down pails into empty wells
Growing old with bringing nothing up.

Must he not, Gellius asks, unroll and read through many a scroll, from which he can take little or nothing? History requires uninterrupted care and time to be written, says Cicero.[52] Dio informs us he spent ten years collecting and twelve more in writing Roman history to the death of Severus.[53] It is "exhaustive and exhausting" labor to write history, a modern historian says. Anyone who has tried it will not gainsay him. Looking back, an historian may with Goethe's Wagner well opine:

Good Heavens! Art is long,
And short is our existence . . .
How hard it is to win the means
By which one rises to the sources!
And 'ere he only gets half way
Must a poor devil likely pass away.

Now all would be simple if an historian, as Tristram Shandy says, could only "drive on his history, as a muleteer drives on his mule — straight forward — for instance, from Rome all the way to Loretto . . . [for then] he might venture to foretell you to an hour when he should get to his journey's end. . . ."[54] It is, however, quite impossible. Nor can one say that the reading of guides to historical method will make the road easy! Indeed, so strait is the gate and narrow the way of historical research, as detailed by certain more extensive, meticulous guides to historical method — for example, Ernst Bernheim's *Lehrbuch der Historischen Methode* — that would-be historians, if they began with a reading of them, might swoon as did Dante when he saw over the gate of Hell: "Abandon all hope, ye who enter." In any case, much that has been written on method is fully comprehensible only to those who have already engaged in historical research. The best policy is to study somewhat simpler guides first, and continue to extend one's acquaintance with works on method, joining theory with practice.[55]

Qualifications of the Historian: Freedom From Prejudice

To catalogue all the qualifications an historian should possess would be tedious, to say the least, if not impossible. Risking oversimplification, a few of central importance deserve stress. Freedom from prejudice, a certain disinterestedness, oft-noted as necessary for the scientist, is no less needed by historians. It is, of course, recognized that completely objective history is impossible; and biased history, as we have noted, has had, and has, its defenders. Certainly, objectivity is hard to achieve. Scientists, too, were once blinded to reality by all sorts of obscure preconceptions. Stefansson, in *The Arctic in Fact and Fable*,[56] notes how long certain ancient dogmatic theories regarding the Northland persisted, and kept men from the truth, till at

[49] Huxley, T. H.: "The Method of Scientific Discovery," *Essays for College Men*, 105, 108; *cf.* Dewey, J.: *How We Think*.

[50] *On the Origin of Species*, 17.

[51] Mention is made of the questionnaire, in passing, for the purpose of warning that it is no method for historians, however much it may be thought to serve others. As Abraham Flexner wrote, ". . . the questionnaire is not a scientific implement: it is only a cheap, easy, and rapid method of obtaining information or non-information — one never knows which. No effort has been made to use it in experimental sciences; it is worth hardly more in education, law, and the other social sciences, for words never mean precisely the same things to different persons, and there is no possible way of discounting poor analytic capacity or the practical joker." — *Universities American English German*, 125. For the reaction of an intelligent person on receipt of a questionnaire, see J. W. Krutch, "Scholarship by Proxy," *The Nation*, Oct. 17, 1936, pp. 451-452.

[52] *Laws*, I, 3. (Trans. by C. W. Keyes)

[53] *Dio's Roman History*, LXXIII, 23. (Trans. by E. Cary)

[54] Sterne, L.: *Tristram Shandy*, 30-31.

[55] Certain brief, simple introductions are starred in the bibliography.

[56] Pp. 11 *ff*.

last they set out courageously to put them to test. Only by painstaking effort have they been set aside. Historians, chroniclers, have often been similarly handicapped by dogma and prejudice. Nationalism distorts most histories today. Temperley wisely argues that national history will be more important when it gains "something of an international outlook." Clio, if she is to be safe, has no use for devotees who carry concealed weapons. Her acolytes should remember Bacon's idols of the mind — those preconceptions arising from tribe, cave, market place, theater.[87] By taking critical cognizance of them, banishing them if possible, one makes a first step towards seeing and recognizing reality. The advice of Pythagoras—[88] "When you are travelling abroad, look not back at your own borders" — should be cherished by social scientists, whether they journey physically, or seek through books and documents, to study the ways of other times and peoples.

Skepticism

Of skepticism, the historian stands constantly in great need. It is his duty to doubt witnesses before he accepts or rejects them. Ancient authors, though they often appear exceedingly credulous, came to recognize the salutary rôle of doubt on man's enlightenment. Modern writers should profit by the solemn teaching of Epicharmus —

A sober sense of honest doubt
Keeps human reason hale and stout —

and eschew Plutarch's advice, that one "should not be incredulous" of great marvels.[89] Even Plutarch, at times, was inclined to doubt the miracles of his day.[90] And if a Polybius at times renounced skepticism, agreeing to accept a supernatural explanation for things too hard for a mere man to understand, one must remember his general injunction to doubt. Authors have often related marvelous traditions, yet denied their universal acceptance of them. Pausanias felt "bound to record the Greek traditions," but "not bound to believe them all."[91]

Natural Endowments

Certain native endowments — mental and physical, if one need preserve the dichotomy — are indispensable to the historian: restless curiosity; quickness of eye and mind; readiness to remember; lively imagination and inventiveness; tireless energy and willingness to spend it unstintingly, for Cicero rightly reckoned indolence and inertness among the hindrances to advancement of science; zealous determination to follow every lead. In short, an historian ideally should have something of genius — "an infinite capacity for taking pains" — which implies a sense of humor and humility as well.

Acquired Knowledge and Skills

To natural qualities much must be added: knowledge and skills in auxiliary fields. These, ideally, are almost unlimited. Nothing is foreign to history. Anthropology, archaeology, astronomy, cartography, chronology, diplomatics, economics, education, exact sciences, genealogy, geography, geology, heraldry, historical method and philosophies, languages, law, literature, military affairs, natural history, numismatics, paleontology, paleography, philosophy, philately, politics, psychology — the list is endless — have been reckoned as part of the historian's equipment. The list, though incomplete, reminds one of all an orator was to know in the days of Quintilian. In reality, no one ever acquires all related knowledge he desires. Even Petrarch regrets that Homer is dumb to him, or he is deaf to Homer. Who has mourned no lack? Actually, since it is impractical to have a knowledge of everything, one must frequently set out to acquire those aids which are indispensable for work in the particular chosen area.

Abiding Interest in Historical Study

Finally, there must be an abiding love of one's chosen field, a conviction that historical research is peculiarly attractive and satisfying — relatively more so than other fields of scientific endeavor — perchance, that it may prove of permanent value and be, as Thucydides thought, a joy forever. Such a conviction as to the worth of historical study should be joined with a deep-rooted interest in the particular problem selected for study. Such an interest, an inner drive which dispenses largely with other encouragement and turns work into play, or at least makes it the most pleasing, engrossing occupation, can be relied on to sustain the burden and heat of days that lengthen into years, and years into decades.

[87] *The Novum Organon*, I, 39-44. (Trans. by G. W. Kitchin)
[88] *Diogenes Laërtius, The Lives and Opinions of Eminent Philosophers*, XVII. (Trans. by C. D. Yonge)
[89] *Romulus*, VIII. (Trans. by B. Perrin)
[90] *Coriolanus*, XXXVIII.
[91] *Description of Greece*, VI, 3, 8. (Trans. by J. G. Frazer)

A Pattern of Excellence

Dio claimed a divine command to write history, and reckoned *Fortuna* as his inspirer in days of weariness. Modern chroniclers may disdain the divine afflatus; but an image of human excellence will not be amiss. Lucian, rhetorician and satirist, more famous for the fanciful lies in his *True History* than for anything else, drew such a portrait of perfection, as though he had Thucydides, Polybius, Cicero, Tacitus before him.[43] Political insight, fearlessness, incorruptibility, independence, frankness, veracity, impartiality, kindness (not too much), literary learning, and fidelity to facts distinguish his model historian. More persuasive, perhaps, is the measured advice of Polybius, ever since recognized as worthy of remembrance:

"In other relations of life we should not perhaps exclude all such favouritism; for a good man should love his friends and his country, he should share the hatreds and attachments of his friends; but he who assumes the character of a historian must ignore everything of the sort, and often, if their actions demand this, speak good of his enemies and honour them with the highest praises while criticizing and even reproaching roundly his closest friends, should the errors of their conduct impose this duty on him. For just as a living creature which has lost its eyesight is wholly incapacitated, so if History is stripped of her truth all that is left is but an idle tale. We should therefore not shrink from accusing our friends or praising our enemies; nor need we be shy of sometimes praising and sometimes blaming the same people, since it is neither possible that men in the actual business of life should always be in the right, nor is it probable that they should be always mistaken. We must therefore disregard the actors in our narrative and apply to the actions such terms and such criticism as they deserve."[44]

Selection of Subject: Principles Involved

In selecting a subject, three chief principles should guide: significance; appropriate humility; availability of sources. The first principle, *significance*, should be observed as a counterweight to the second, which, if carried to extremes, might end in trivia. Everything has history, but all histories are not equally important. Lynd,[45] a few years ago, wisely warned historians — and other social scientists as well — against losing themselves in matters of no importance. Each student, certainly, should select for study that which is of moment — commensurable with his ability and interest; and he should gather facts for a purpose, remembering that forming and testing hypotheses may be fruitful in history as in other fields of study.

Modesty and humility are outstanding traits of true scientists. In contrast to metaphysicians and astrologers of prescientific ages, who sought to furnish universal answers to the questions of whence and whither, deducing all from some first premise, modern scientists exhibit a marked humility, a willingness to begin with a small province, observe, record, classify faithfully, draw conclusions slowly and sparingly, so far as warranted, and perhaps, at last, put the whole together to read the riddle of the universe. No doubt, there were arrogance and bombast now and then, not alone in Paracelsus and Tycho Brahe. It is significant, however, that Tycho set himself the modest goal of cataloguing a thousand stars, and died when some three hundred short of his mark.

Historians who seek to come close to reality, follow the lead of the pioneering scientists. They are content to till modest fields, having faith that only on the basis of established facts can one expect ultimately to gain an understanding of the whole. World history, in truth, cannot be written as Augustine sought to write it. There must be laborious grubbing before sound foundations for the superstructure of universal history can be laid. A full, accurate history of a nation must rest on a solid substratum of local history. Anyone who faithfully gathers, organizes, interprets the facts of a life, an institution, a movement, does well, even though he may never see the whole edifice into which his own bit of reconstruction ultimately finds its way.

A third principle, *availability of sources*, seems obvious enough. History is an indirect science. The historian cannot observe events, or set up experiments; he must find sources, direct or indirect evidence, from which what was felt, thought, proposed, brought to pass, may be judged with a sufficient degree of

[43] "The Way to Write History," *The Works of Lucian of Samosata*, 54-55. (Trans. by H. W. Fowler and F. G. Fowler)

[44] *Polybius*, I, 14. (Trans. by W. R. Paton) Loeb Classical Library. Reprinted by permission of the publishers, Harvard University Press, Cambridge, Mass., 1922.

[45] *Knowledge for What?*

reliability. These sources fall, first, into two broad classes: primary, or original; secondary, or derived. Original sources may be thus classified: (1) tangible remains — implements of work and play, architectural structures, food, clothing, ornaments, *et cetera;* (2) oral tradition — folk legends, songs, family stories; (3) documents — letters, personal diaries, account books, genealogies, inscriptions, contemporary chronicles, newspapers, drawings, photographs, official journals, laws, court decisions, church records, charters, curricula, books, recordings and films; (4) testimony of living eyewitnesses and other survivors.

Importance of Original Sources

The importance of original sources cannot be overestimated. Without them history would be only an empty tale, signifying nothing. He who traces developments from their first origin has the best view of them, says Aristotle.[66] Now the historian cannot witness events before his time; always he must turn to the closest possible witness of what happened. Hence arises the value of tangible remains, eyewitness accounts, contemporary chronicles, original manuscripts, first editions.

Antiquity confers authority, says Tertullian;[67] but it is not age alone that renders ancient accounts valuable. Assurance of actual observation, competence and integrity of the observer, and ability to report what took place — all enter into the computation of value. Whatever may be said for or against him, Thucydides' value for us is enhanced by the fact that he was "personally present" at some of the events, and because he sought to investigate "accurately in every particular" accounts related by others, judging the varying tales of witnesses, and sought to avoid giving credence to mere hearsay.[68] Josephus, who says he first fought against the Romans, turned historian of that struggle, to give Romans an account of the facts, endeavoring "faithfully" to "recount the actions of both combatants."[69] Pliny witnessed the eruption of Vesuvius, and tells of reactions to it — though he fears it may be beneath the dignity of history to do so.[70] Tacitus found his days dolorous, but his value to us is great because he thought that "carefully noting and recording this period," when Rome had become the realm of a single despot, was worth while.[71] Galen's comments on athletes and athletics, his views on the place and kind of exercises and diet in relation to health, and his treatise "On the Small Ball" are valuable evidence on such matters in the second century of the Roman Empire, being results of first-hand observation, scientific study and practice.[72] Philostratos' *Concerning Gymnastics* has value, but of a different order. Though a contemporary source, it is the work of a man of letters and reads like a compilation from handbooks rather than first-hand observation.[73] Dio's value increases when he writes of things seen and heard at events which he attended, or in which he participated.[74] Procopius[75] grips attention by his record of the times of Justinian and Theodora, although he tells of things which he fears "will seem neither credible nor probable" to later generations.

Visitation of Place of Origin

Besides reading original sources it is eminently desirable to visit the *locus* of origin and reference, whether they pertain to a person, a people, a movement. By visitation of the place where events took place, or reputedly did so, one may locate other first-hand sources; and, also of great importance, one may learn better how to read and interpret all evidence, primary and secondary, which bears on the subject. A Libyan, Aristotle says,[76] when asked what was the best manure, replied: "The landowner's foot-prints." Asked about the best feed to fatten a horse, a Persian answered: "His master's eye." Paraphrased for the historian, this means that setting his feet where his subject trod is one way to enhance the vitality and vigor of his history. Philostratos thus describes his quest for details of the life of Apollonius of Tyana: "I collected the material in the cities that loved him, in the temples whose services he reformed, from reports others gave of him, and from his own letters."

For students of American educational history, physical and intellectual, the injunction to

[66] *Politica,* I, 1-2. *The Works of Aristotle.* (Trans. under the editorship of J. A. Smith and W. D. Ross)

[67] *Apology,* XIX; with *De Spectaculis.* (Trans. by T. R. Glover; with G. H. Rendall's *Minucius Felix*)

[68] Thucydides: *op. cit.,* I, 22.

[69] *The Jewish War,* I, 1-4. (*Josephus.* Trans. by H. St. J. Thackeray and R. Marcus)

[70] *Letters,* VI, 20. (Trans. by W. Melmoth; rev. by W. M. L. Hutchinson)

[71] *Annals,* IV, 32-33. (Trans. by A. J. Church and W. J. Brodribb)

[72] "De Parvae Pilae Exercitio," *Opera Omnia,* V, 899, *pass.* (Ed. by D. C. G. Kühn)

[73] Woody, T.: "Philostratos: Concerning Gymnastics." *The Research Quarterly* (May, 1936) VII, 1-5.

[74] Bk. LXXIII, 18-19.

[75] *Secret History,* I, 1-5. (Trans. by H. B. Dewing)

[76] *Oeconomica,* I, 6.

visit *loci* of origin is even more weighty than in some other fields. Too many educational histories have been written in The Central Library. Education was for long almost wholly a local and private function. Local records have commonly been neglected and are not assembled in a central place. Its history must be followed in the byways, not only on the highways. This was first impressed on the author by the study of Quaker education in Pennsylvania and New Jersey, at a time when sources were still widely scattered. Now, many more manuscripts have been collected in central depositories. Likewise, study of the history of women's education in the United States involved thousands of miles of travel to reach many local sources.

Others have taken to the road. A few are named, not to immortalize men and women in a footnote (as Schliemann once promised a young Yankee archaeological assistant he would do!), but simply by documentation to emphasize a phase of method, hoping thereby to lure others to the way. Emma Bolzau[76] followed the peregrinations of Phelps. Mae Harveson[77] pursued the ghost of Beecher in the East and "at the West." Restless Eaton led Ethel McAllister[78] a merry chase through matrimonial mazes, land deals, prison, freedom, lecture tours, to the founding of his Institute. James Mulhern[79] found documents in "them thar hills" of Pennsylvania. Other examples might be named; yet the work — *i. e.* first-hand work — is scarcely begun.

If really little has been done by digging in the local quarries of intellectual history, less has been attempted in regard to physical education. The two need not be wholly separate, yet actual divorcement in past eras tends to make the writing of their history so. Institutions, movements, men and women, associated with the development of play and physical education, are waiting for an historic interview. Nothing would facilitate the work more than the collection of *primary sources* at a central place, or in regional research centers, or stimulating local institutions to form and keep systematically their own archives. Naturally, too, the assembly of *secondary* materials, assuming that they be carefully written, documented, and supplied with bibliographies, would be of great value. The American Association for Health, Physical Education and Recreation deserves to be congratulated on the formation of a National Committee on Permanent Historical Records and Exhibits.[80]

All will recall that fascinating picture, garrulous old Nestor coaching young Antilochos how to drive, so as to win the race. Back-seat drivers are funny wherever found! Who would be one? But one fancies that the ghost of Philostratos would whisper in the ear of the Chairman: "Let the members of the Committee hearten themselves and their deputies to visit sand lots, gymnasiums, school buildings, newspaper offices, local libraries, burying grounds, old houses (especially attics), of course not neglecting to 'bite the ear' of inhabitants — to borrow journalistic coin. In general, to change the figure, let them drain the local headwaters and channel them to the great lakes and the sea."

Careless Handling, Destruction of Manuscripts

For historical inquirers there is probably no more painful experience than finding that valuable manuscripts by or about their subjects, even though of no great antiquity, are being badly cared for; or, worse, have just been thoughtlessly destroyed. The tooth of time is ruthless and sharp enough; it hurts when someone insists on filing it! The author found *MS.* minute books of the eighteenth century lying on the lower shelf of a little stand at the home of an old gentleman near Mt. Holly, New Jersey. Bolzau met an old man who remembered seeing his father burn certain Phelps diaries and letters one by one in the fireplace. If ever, she must then have had murder in her heart! Robert Mohr[81] learned from Richard McCaskey that he had made a "huge bonfire" of "Jack" McCaskey's "stuff," among which almost certainly were Burrowes letters. Chagrin on such occasions must nearly match the rage that stirs (but must be choked, politely) when someone has manuscripts but jealously refuses to let you see or touch them.

Quest for Manuscripts

Milton once compared himself to a small boy who picks up a particularly bright pebble or shell upon the beach, while all around is an ocean of unexplored realms of truth. A

[76] *Almira Hart Lincoln Phelps, Her Life and Work.*
[77] *Catharine Esther Beecher, Pioneer Educator.*
[78] *Amos Eaton.*
[79] *A History of Secondary Education in Pennsylvania.*

[80] Created in 1934-1935, it became a standing committee in 1937, and was under the chairmanship of Professor Frederick W. Luehring, University of Pennsylvania, 1942-1946. Karl C. H. Oermann, Assoc. Professor of Physical Education, University of Pittsburgh, is now chairman.
[81] *Thomas Henry Burrowes.*

mere antiquarian collector, seeking tangible remains, traditions, stamps, manuscripts, seems but the image of such a boy grown old. His is a useful work. Everyone collects something, be it string, bags, buttons, bottlecaps. Historians, one may hope, collect with more serious, better-directed purposes. Gellius speaks somewhat disparagingly of those who gather materials, reading "with a white line," without discrimination.[83] He himself was scarcely free from that disease. Yet even the serious seeker must now and then break ranks, fall out into the lanes and wander over the leaves of nature's book. There is value in it.

Trevelyan,[84] who thought his legs his best doctors, made a marriage of walking and history, and found that it bred skepticism as to some of Macaulay's majestic phrases. He adds, dryly, "But Macaulay was not much of a walker across country." Nearly thirty years ago, I read J. R. Coxe's English epitome of Galen and Hippocrates. Just a short while back, threading my way slowly along an abandoned roadway, overgrown with briars and saplings of two decades, I found in an unoccupied, old stone house a yellowed medical manuscript, whose contents suggest that in all truth it was really Galen and Hippocrates who doctored Pennsylvania Dutchmen, though they called their doctor: Hamer.[84] From that document and others associated with it, the line ran back through three generations of Hamer doctors, the first of whom studied medicine in the eighteenth century with Dr. Griffith of Bucks County.

Many a document may well seem to be worth much less than the labor spent upon it. There may, or may not, be any rhyme or reason to the discovery and reclamation. One stumbles on them unexpectedly, perhaps; again, one may search for years for something, and even then be very lucky to find it. Twenty years ago the author looked long for original sources of an old seminary in a Southern town. Various leads ended in nothing. The local librarian assured me there was not a trace of anything in her domain. There was no catalogue of the holdings. I planned a visit there. Some years later, journeying to the place, I engaged a greybearded teller of the most prominent bank on Main Street in conversation. He knew nothing himself, but he had a friend. "Dio—," he said, "knows all about the old school, his mother attended it. . . . Though he lives distant in the country, he frequently comes to town, might be here this very day." Walking with me to the street, he shaded his eyes, peering this way and that. Suddenly, his voice quickening, "There he comes now," he said, and pointed to a tall, spare man, straight as a ramrod, coming down the other side. He hailed him.

Dio told all. But, mindful of an old man's memory, I reminded him that I would like to find the written documents, manuscripts, covering the founding and other details of the institution's earliest years. At that, a light appeared in Dio's eyes. "If that's what you want, come with me." He led me diagonally across the street to the little library. Nodding casually to the surprised librarian, who had no idea what treasures were housed under her roof, Dio went over to the wainscoted walls, pulled out a few drawers, drew from one a longish yellow manuscript, and said, "Would this be what you mean, mister? Nobody knows it's here but me. I put it there." In his hands he held the original Minute Book of the Trustees, 1835-1860.

Reading and Weighing Sources

While using every source, certain matters need ever to be kept in mind: no matter what it may be — tangible remains, a memory recounted orally, a manuscript, a contemporary chronicle, a history written long after the event — it is only a more or less intimate, conscious or unconscious, testimony about the fact — not the event or fact itself. Manuscripts are prior to printed sources, therefore more valuable (unless perchance, for example, the printed work may be a critical text based on collation of all the manuscripts), but they must nevertheless be subjected to critical examination. Systematic doubt towards all sources is the beginning of historical wisdom; it sharpens the eye and the ear in all testing of materials to determine the degree of their reliability.

External Criticism: Authorship, Time and Place of Origin

Assuming a document has been discovered, and that it can be read,[85] the first problem is to

[83] *Attic Nights*, preface, I, xxxi. (Trans. by J. C. Rolfe)

[84] *Op. cit.*, 73.

[84] Woody, T.: "Medical Views of a Pennsylvania Doctor in 1850." *Bulletin of the History of Medicine* (Apr., 1945) XVII, 385-414.

[85] The highly specialized problems of learning to read a written source, for example, the characters of Mohenjo-Daro, Minoan script, Etruscan fragments, are not of importance here, yet a study of the process of the specialists who explore such arcana is highly interesting and suggestive to historical inquirers. See Evans, A. J., *Scripta Minoa*, Vol. I.

determine authorship, whether it be authentic or a forgery,[86] time, place, and occasion of origin. These are commonly not stated in old documents. Even when they are given, the question of their correctness is to be answered. For works are often ascribed to other persons than the real writer; and, especially in time of war, we have ever-fresh evidence of documents purporting to come from sources other than the true ones. Without ascertaining them with a satisfactory degree of definiteness, the document will be worthless, or nearly so. Yet, it may be, not all of these can be determined. Authorship is important; much may remain obscure without it, which would at once become clear on its establishment. Yet, even if authorship be still uncertain, if time and place can be fixed, the document can be of definite use. Authorship of many works of antiquity is still disputed. The work of establishing such facts and probabilities is commonly called *external* criticism. When these are established, one may proceed to internal criticism and interpretation of the document.[87]

Example of an Undated *MS.* of Unknown Authorship

Let us take a not too difficult example, yet one in which by no means all the answers to authorship have been found. Perhaps more extensive and intensive inquiry would clear up remaining uncertainties. In the University of Pennsylvania Archives is found a manuscript, without author, date, or place. There is no external indication of its source, whether by gift or purchase; it is in relatively good condition, but apparently old; there is no sign of later alteration, or intentional mutilation. The fact of its being among other original manuscripts related to the University suggests, but does not prove, its relevance thereto. It is called "Observations for the Explication of the foregoing Accounts." Study of the entire text leads to certain tentative observations, hypotheses which may perhaps be checked by other sources:

A. It may be (1) an original document, or part of one, which was sent to some inquirer, who had requested detailed information regarding the plan and operation of the *Pädagogium Regii;* or (2) a translation of some published account of the rules and operation of that institution.

B. It may be either a translation of some original manuscript account, or of a printed document, or, perhaps, an original manuscript by someone unfamiliar with English, judging from certain awkward passages: (1) "when there is any thing to be write on the Table . . ." (p. 25); (2) "by Departure" (p. 26); (3) "of the in so many Schools usual froliks . . ." (p. 28).

C. It seems almost a certainty, too, that the translator, or the original author, was giving information which he intended to be useful in Pennsylvania, for he is at pains to give the equivalent of sums of money in Pennsylvania currency.

D. That the document refers to the *Pädagogium Regii,* one of the institutions established at Halle, 1695, as a result of the labors of Francke, also seems clear from the text, there being specific references to an "Orphan-House," (pp. 15, 37, 38), *i. e.* the *Waisenanstalt,* which Francke established in keeping with his philanthropic pietism. There is also a reference to the propriety of praying for the welfare of the "University," which would seem to be the University of Halle (Hall). The age of pupils admitted, the social strata — nobility and the well-to-do—from which pupils came, seem to fit with information commonly known or ascertainable relative to the *Pädagogium.*

E. The account appears to have been written quite some time after the institution it describes had been established (Article 2); moreover, reference is made to 1726, after which date this particular manuscript seems to have been produced.

These are the chief facts and inferences to be gathered from the manuscript. Without more than the internal evidence, the document would be a stimulus to speculation, but little else. Turning to the most promising original source, from which corroboration of inferences might be gained — the Trustees' Minutes — the following facts are ascertained: (1) It is evident that for several months the Trustees were much concerned about drawing up regulations for the institution recently established under

[86] For an account of some of the most remarkable cases, and the methods of detecting them, see J. A. Farrer's *Literary Forgeries.*

[87] Since the appearance of Bernheim's *Lehrbuch* (1889) and Langlois and Seignobos' *Introduction* (1897), a host of books have been published, many of which are deeply indebted to them. For extensive, thorough accounts of external and internal criticism, readers may still turn to Bernheim, *op. cit.,* 324-561, and Langlois and Seignobos, *op. cit.,* 71-208. The essence of such matters is also presented by H. B. George's *Historical Evidence,* 29-219; and J. M. Vincent's *Historical Research,* 19-260; shorter, but full enough to be suggestive, are F. M. Fling's *Outline of Historical Method,* 26-86; and R. L. Marshall's *The Historical Criticism of Documents,* 12-59.

the guiding influence of Franklin and put under their care. Thus, 23/February/1750/1, Mr. Richard Peters, one of the committee to draw up regulations for the several schools, reported that their work had encountered "some Difficulty" and asked for more time. The committee was urged to use "all the dispatch they can."[88] On 16/April/1751, the committee on regulations was not yet able to report, and was asked to have its statement ready for the next meeting. A month later, 14/May/1751, the rules committee was still unable to report; likewise, 11/June/1751, the rules were not yet ready.

On September 10, 1751, it appears that difficulties still confronted the committee on regulations. A minute indicates that the committee wished to seek light on the problem by consulting the experience of a well-known institution for the education of boys that had been set up at Halle:

"The Committee for forming Rules for the better Regulation of the Schools, having found some Difficulties in that Matter, proposed to the Trustees to get a Translation made of a Pamphlet written in the German Language, recommended by the Revd. Mr. Whitefield, containing the Rules and Orders observed in the celebrated ..... School at Hall [Halle] in Saxony, which being formed upon many Years Experience, it was supposed might furnish the Trustees with some useful Presidents on this Occasion. Which Proposal was unanimously agreed to, and the Committee are desired to get the said Pamphlet translated accordingly."[89]

From the foregoing, it seems reasonably certain, but the proof is not complete, that the English manuscript *may be the translation* of a document which, presumably, Mr. Whitefield had in his possession. That Whitefield was an enthusiastic admirer of the philanthropic institutions established by Francke at Glaucha, near Halle, is evident from numerous passages in his letters and in the accounts of his labors. Further search would probably lead to discovery of the original pamphlet, or a copy of the same, from which this *MS.* translation was made, and many other matters. But this will suffice to indicate the initial steps in attempting to discover authorship, place, time, and purpose in a document where none of these are given.

[88] Minutes, I, 8¼.
[89] *Ibid.*, 15.

Internal Criticism: Sources of Doubt

A lawyer hears a witness testify, and subjects him to cross-examination. An historian occupies a comparable situation *vis-à-vis* a host of witnesses. The difficulties, however, are greater in his case: some of them are mute remains, from which he infers testimony; others, once living, speaking, writing, are now inanimate; still others, eyewitnesses, may survive.

In questioning and cross-questioning, the historian may well remember the wisdom of Job: "all men are liars," — some consciously so, others unconsciously. He must also keep before him the psychological fact that even though the eyewitnesses were all present at a certain event, they may have actually *seen* or *heard* different aspects of it, or perhaps if they viewed or listened to identical events, these meant quite different things to them, and were only more or less fully and accurately reported. In short, many things reported are simply errors of observing, reporting, or subsequent transmitting of reports; others are willful perversions. The competence of the observer to report on matters, his integrity, or bias, and the purpose for which the record was originally made, all enter into the final judgment of its value. Certain grounds for doubting an author have long been familiar: his self-interest in deception; group membership which would limit freedom; bias of any kind that could bear on the subject; evident desire to court favor; servility towards conventions; artificial embellishments.[90]

Time has been called the "incorruptible witness." Livy speaks of writing as "the sole faithful guardian of the memory of past deeds." In a literary age, people come to trust writing more than memory. The phrase suggests a trust in written documents, however, greater than an historian should concede them. Roman history was falsified, Cicero says,[91] by family pedigrees manufactured in an age of letters. Diplomatic documents are properly regarded by historians as a choice field of frauds. In fact, written documents at once make possible the writing of more accurate history and make the historian's task more onerous as their number increases. Jeudwine[92] maintains that under certain conditions oral tradition may be a surer guardian than written sources.

[90] Langlois and Seignobos, *op. cit.*, 164-172, give an extended discussion of these.
[91] *Brutus*, 16. (Trans. by G. L. Hendrickson; with H. M. Hubbell's *Orator*)
[92] *Op. cit.*, 133 *f.*

Guiding Principles

Since neither antiquity, nor memory, nor written characters are truly incorruptible witnesses, historians must approach all of them with critical doubt. Certain general principles, to be observed in reading and judging sources, may be briefly put: (1) do not read into earlier documents the conceptions of later times; (2) do not judge an author ignorant of certain events, necessarily, because he fails to mention them (the argument *ex silentio*), or that they did not occur, for the same reason; (3) underestimating a source is no less an error than overestimating it in the same degree, and there is no more virtue in placing an event too late than in dating it too early by the same number of years or centuries; (4) a single true source may establish the existence of an idea, but other direct, competent, independent witnesses are required to prove the reality of events or objective facts; (5) identical errors prove the dependence of sources on each other, or a common source; (6) if witnesses contradict each other on a certain point, one or the other may be true, but both may be in error; (7) direct, competent, independent witnesses who report the same central fact and also many peripheral matters in a casual way may be accepted for the points of their agreement; (8) official testimony, oral or written, must be compared with unofficial testimony whenever possible, for neither one nor the other is alone sufficient; (9) a document may provide competent and dependable evidence on certain points, yet carry no weight in respect to others it mentions.

Intermixture of Primary and Secondary Evidence

A word more must be said of the last stated principle, for it is a natural tendency to give general credit to an authority when its competency for particular matters has been accepted. On the contrary, however, one must learn to discriminate, in one and the same source, between elements for which it is to be considered a primary witness, and others for which it is only a derived authority. For example, the above-named doctor's manuscript is a primary source as to the reality of his opinions and direct observations, yet not primary for matters he attributes to ancient physicians, or in regard to a plague's destructiveness in India. A school's published advertisement is a primary source for what the school professed to teach, the charges to be made therefor, the name of the proprietor-master, but there is no primary value in its published claim that it is the first institution to teach such subjects, or establish such standards. A history textbook used in schools is a primary source for what those schools sought to teach, but is not primary for particular facts related of antiquity. A newspaper editorial may be a valuable primary source for political opinion of the day, yet not primary for historical facts to which it alludes to persuade its readers. Livy was a living witness of some events of his later history, whereas for matters related about earlier centuries he is neither a primary source, nor did he have original sources on which to base his account.

Vary the situation somewhat: even a writer of contemporary events, such as the author of an autobiography, is not to be regarded as primary authority for a host of things he puts into it. Always the historian's question must be: had the author a sufficiently intimate status, in time, place, competence, to qualify him to bear first-hand and reliable witness on the particular point at issue. E. E. Hale[28] is a more or less valuable first-hand witness as to "The Swimming School," which he says he attended in Boston. He is not, however, primary authority on the subject of swimming schools in general, or even for his own generation.

Secondary or Derived Accounts

Secondary works serve useful, legitimate ends: they furnish background on matters for which the use of primary sources is impossible; they are the means by which one rises to the original sources. But use of them requires great care. Reading and interpreting a secondary work is in certain respects easier, but in others more difficult, than a primary one whose origin has been established. It is farther removed from the event, a host of other authorities may intervene. The secondary work may be based wholly or only in part on primary sources; or it may be compiled wholly from other secondary writers; perhaps, therefore, such a document should be called tertiary. In proportion as a secondary authority has gone back to primary sources, assuming for the moment their proper use, its value is enhanced. If it contains significant and extensive quoted extracts from originals, it may even

[28] *A New England Boyhood*, chap. 3.

come to be spoken of as a source, or source-book, though it is not, in truth, a primary source, for in every copy some degree of error is certain to enter. In general, some of the same critical principles will have to be observed in judging secondary authorities as in the case of primary materials. In short, the reader will attempt to form careful judgments of an author, in respect to his accuracy in the use of his sources, acuteness of insight and competency in judging, veracity, bias, internal consistency, whether he simply used other secondary works, followed them uncritically, or plagiarized them. Hence arises the importance of exact documentation. If a secondary authority cannot be checked, it is of little scientific use, though, like poetry, it may be suggestive and inspiring.

III
Techniques

Documentation

The fundamental value of scientific historical reporting, in contrast to earlier, purely literary history, rests on its fidelity to principles of method, and on precise documentation which permits rechecking of sources used and the validity of judgments based on them, whereby confidence may be established, or doubt of them confirmed. History that is meant for instruction should be documented. Books which are set up primarily with an eye to cost-and-profit economy may exhibit a clean, streamlined page, unobstructed by footnotes, but they scarcely promote critical examination of history.

Note Taking

Adherence to the principle of precise documentation in the final text requires prior attention to the meticulous making of notes. To write reliable history from memories stored up would be fantastic. Everyone will recall instances when a note should have been made; but the matter was intrusted to memory, in confidence that one would certainly remember such a thing! A year later, five years later, it has been completely forgotten. No amount of work may suffice to recover what a moment spent on making a note would have required. Even if an item were remembered till the ultimate date of composing the text, it would be of no use for documentation.

Notes should be made, therefore, as one goes. They may be of many types — more or less extensive quotations from documents, summaries or paraphrases of the same, inferences made, questions which arise from observations on reading, reminders to compare this authority with another, conflicting statements of facts and views, places to be visited and persons consulted, thoughts that occur in the night, *et cetera*. Often, but not always, the character of a note may depend on the accessibility of the source. A word, a phrase, a query on a small slip of paper may suffice, perhaps, for notes on documents which are always at one's hand. From unique manuscripts, or rare books, which one may have traveled far to consult, it may be necessary to take extensive quotations, make photostats of important parts, prepare a précis of the contents.

The size of note sheets is not unimportant. For great undertakings, covering complex matters, experience dictates that they may well be of several sizes, (large, 8 by 11; medium, 5 by 8; small, 3 by 5), to suit the character of the subject matter and its extent. All should be loose-leaf notes, for the simple reason that such may be shifted with perfect ease and thus facilitate classification and organization of material.

At the top the note should have two items: on one side, a rubric (word, phrase, or sentence), indicating the subject dealt with; on the other, the precise source, author, title, volume and page, or book and section. The place of origin and publisher need not be entered on note sheets; the proper place for them is the bibliographical card, which should be filled out when the document is used. If a quotation of more than a page has been made, it will save future effort to indicate the precise point where one page ends and the next begins, placing the new page in brackets, thus [3], in the text. This will be of great assistance, especially in editing an entire manuscript, where it is desirable to keep the original pagination; also, if one later wants to give a page reference to some specific part of the original quotation.

Organization

The reconstruction, interpretation, conclusions relative to any subject studied take form in the investigator's mind more or less slowly, consciously and unconsciously, as the study of documents proceeds. The investigation which began, probably, as a big "blooming confusion," a dark question, at length reaches some answer, a degree of order, clarity, precision. Assuming the adequacy of sources for the investigation, competence of the inquirer in faithful use of them, and consistent attention to the classification of materials while collecting, a more or less clear outline should be in the author's mind when he finally exhausts the sources. Though clear, the pattern may be general. If there is any lack of clarity of the scheme into which the material should fall, it may be dispelled by a careful restudy of notes taken, scrutinizing the classification so far attempted. Notes carefully made and labeled, and classified while their collection is in process, render relatively easy the task of organization of the text, which might, otherwise, offer almost insurmountable difficulty.

A word may be said of certain common principles of organization: one of the oldest is the *chronological*. Livy employed it in organizing his history from the founding of Rome to his own day. Something can be said for this pattern which puts together the facts of a certain time; but it has marked shortcomings, obviously, since temporal relationship is often of slight importance.

A second principle, the *geographical*, is not only ancient, being commonly combined with the chronological, it may be for certain types of study useful now. This might well be true of the history of a country, in which the author desires to give due prominence to the varying patterns of particular communities composing it; it may also be serviceable in source-books whose purpose is to preserve local sources and their interconnection with places, institutions, persons. In short, the geographical principle offers every opportunity to emphasize the significance of locality in history.

By a third principle, the *topical or logical*, material is organized according to pertinent relationships of ideas, institutions, movements. Topical, logical organization is particularly favorable for attempts to show origin, development, continuity in human affairs, since it permits faithful attention to these matters, while place and time fall into positions of due importance.

It is obvious, of course, that there may be simply an order of priority in respect to these principles of organization, two or more being employed. Thus, if the primary principle be logical, the secondary one may be chronological: within a logically coherent body of material, that which is prior in point of time may be presented first, that of a later time following after.

Composing the Text

If sources have been covered, if notes have been carefully made, studied through critically and properly classified, the organization and composing of the text should occasion no great difficulty. In general, one should have in the mind's eye a pattern of the book or paper before beginning to write. Such a design may emerge fairly early, long before all material has been collected. In fact, one may begin some history, under certain conditions, with a more or less set outline in mind, modifications of it being made as the work progresses. As early as possible, it is advantageous to write out such a tentative outline. Similarly, before beginning to compose a particular chapter, its materials should be carefully and critically gone over in detailed fashion, so that the pattern of it may be quite clear. The titles of books, of chapters, and of other subdivisions, if any, should be carefully chosen, *brevity*, *meaningfulness*, and *imagination* being the chief guiding principles.

Footnotes

The text of any intricate, extensive, serious document will of necessity be written with notes at hand. Quotations, important statements of fact, conflicting views and facts presented by different authorities, paraphrases, conclusions for which the writer may be directly indebted to other sources, even though not quoted, and similar matters should be documented exactly, to show supporting sources. The purpose of footnotes, and the necessity for their being precise and accurate, dictate the principle that documentation should be made as one writes. Do not count on "documenting later." Matters left for "later documentation" will too often be "never documented"; or, if not that, there will be poor economy of time and effort.

Weaknesses of Certain Usages

Several systems of inserting footnotes are employed. A common technique is to place notes at the bottom of the page, identifying by an index figure the relation of each to a word, phrase, sentence, or some larger portion of the text. This method is laborious, involves obvious inconveniences, is less flexible than desirable, and is somewhat conducive to error.

By another technique, notes are placed in a space immediately below the text to which they refer, and are separated from the text above and below by parallel lines. This has certain marked disadvantages: it wastes space, for a short note takes a whole line; moreover, in a heavily documented manuscript, such a placement of notes will render the reading of the text almost impossible.

A More Flexible System Recommended

A better system of documentation is to incorporate the footnotes in the text in brackets as one writes, leaving them for the time being unnumbered. When the manuscript is turned into typescript, it will be found a great convenience, especially in reading back to the original, if the bracketed notes be typed in red, thus standing out conspicuously from the text. If the paper passes through more than one typed edition, as is likely in case of extensive works, the footnotes should not be numbered before the final typing. To that point, numbers serve no purpose. This system is flexible, involves no waste space, and makes for an attractive page. Most important, it is conducive to economy of labor and greater accuracy. For example, supposing that after composition a bit of reorganization and shifting of part of the text is seen to be desirable — and this may happen, no matter how careful the organization before beginning to write — such a transfer may be made readily, since all notes keep their place and go bodily with the material of the text.

What Footnotes Should Contain

When giving footnote citations, care should be taken to begin them with the surname of the author, or with that word in the document which appears first in the bibliographical item. Enough details should be given to identify the material referred to, and to enable readers to turn to the bibliography for fuller information. If no bibliography is to be published, as sometimes is the case, unfortunately, for reasons commercial rather than scholarly, the footnote which first cites a work should give all bibliographical data necessary to locate it. Thereafter, references should be made in a briefer form. Assuming that the bibliography is to be published, however, as it should be, the note, as incorporated and numbered in the final copy for the printer, would appear as in this example:

The worst effect of athletic contests was that they not infrequently resulted in maiming the participants; and, when carried to extremes, as among professionals, the mind itself was reduced to the level of the brute.[37] [[37] *Galien, Oeuvres Anatomiques, Physiologiques et Médicales de,* I, 31-46. (Trans. by C. Daremberg).] Some, keenly sensitive to these evils, were inclined to think that athletic contests should be entirely avoided.

Abbreviated Forms Commonly Used

If the note immediately following refers to the same authority, conventional practice saves time and space by a shorter form, *ibid. (ibidem),* "the same," as in the following:

A celebrated physician, who had become acquainted with various Greek philosophical systems before he took up the study of medicine, declared that "the good physician is a good philosopher."[38] [[38] *Ibid.,* 1 *ff.*] It need not follow that good philosophers are also good physicians. Galen, a philosopher as well as a doctor, who was profoundly disturbed at the evil effects of professional athletics on mind and body, recommended less violent sport, such as he described in his treatise, *De Parvae Pilae Exercitio.*[39] [[39] *Galeni, Claudii, Opera Omnia,* V, 899-910.] The evils of professionalism,[40] [[40] Manning, C. A.: "Professionalism in Greek Athletics." *Class. Wkly.* (Dec. 17, 1917) XI, 74-78; Woody, T.: "Professionalism and the Decay of Greek Athletics." *Sch. and Soc.* (Apr. 23, 1938) XLVII, 521-528.] however, though sharply criticized, were incapable of reformation.

When a work has once been cited in a chapter, and another one or several have followed it in the notes, it is common practice to employ *op. cit. (opere citato),* "in the work cited," when a new reference to the first one is required. Such a case, a reference to Daremberg's translation above, follows:

The athletic contests of professionals often wore them out quickly. Fuscus, a runner, who

was credited with winning fifty-three races at Rome, and others elsewhere, died at the age of twenty-four.[83] [[83]Galien: *op. cit.*, I, 38; Friedländer, L.: *Roman Life and Manners under the Early Empire*, II, 21. (Trans. by L. A. Magnus, *et al.*)] Athletes began to compete when young and made great records. Tales of their prowess are often quite fantastic.

A reference to a periodical article, which has been previously cited in full, and has been followed by other footnotes, may be shortened by use of *loc. cit. (loco citato)*, "in the place cited," for example:

"When we speak of professionalism as existing under the Greek athletic system," Manning[88] [[88]*Loc. cit.*, 74.] says, "we must beware of using the word professionalism with all of its modern connotations, for officially the Greeks never made any distinction between amateur and professional athletics."

The *ff.* in sample note 28 above (or *et seqq.*, if preferred) means two or more pages following; one *f.* (or *et seq.)* is used to indicate one page following. Consecutive material covering a definite extent of pages should be given, as in *Galeni* above, 899-910. After a page number, *et passim* may be used to cover scattered references in a document. Cross-references to other parts of the text may be indicated in the footnotes by *supra*, "above," and *infra*, "below," giving the page or pages.

Footnotes were formerly indicated by asterisks and other figures. Sometimes they are numbered consecutively beginning anew with each page. The best practice is to number them consecutively throughout the chapter. In printed form they should appear at the foot of the page. The practice of assembling notes at the end of each chapter, or even at the end of the volume, has been growing, unfortunately. It does not serve critical readers, for whom the notes are supplied, as anybody knows who seeks to review books carefully, or has occasion for critical use of them in his own work. For the labor of turning to the end of a book wears out, unnecessarily, both the user and the volume itself. When the text is complete, the footnotes should be read to the bibliography, to make sure that each authority cited in the volume is in the bibliography, and that one "tracks" with the other, so as to be readily found.

Bibliography

A list of all materials should be supplied with every piece of historical research. The bibliography is, first of all, a tool shaped by the investigator for his own use; secondly, in published form, it should be most readily serviceable to others who read the work critically and may use it in still further study. Every bit of research should be of assistance to another. Final preparation of the bibliography for publication demands relatively little labor, if it has been built up properly as the investigation progressed.

From beginning to the end of a study, each item should be listed on a 3 by 5 library card. Besides the description of the document, the library number, and some indication of the place where found, should be given for economy of time. In case of untitled manuscripts, items of original remains, and other unique materials, descriptions may vary considerably, but each should be described as exactly as possible, fullness being carried only to the point of ready identification. In short, a rubric may be invented, if no original title is on the document, which should indicate its character, authorship, date, place of origin, or the probabilities as to such matters, and the place where it is found. For example:

> Marsh, Ann: a photostat of her account book, showing amounts received for teaching boys and girls in Philadelphia, 1771-1789. 17 numbered pages. Made for Thomas Woody from original *MS.*, loaned by John Phillips, a student in The College, University of Pennsylvania, 1925. In possession of his family, near Downington, Pa.

Books

In case of books, the author, title, publisher, place and date of publication are necessary. If it is a translation, the translator should be named. If there is more than one volume, state the number. Underline the exact title to indicate that it should be italicized in print. First names may be given in full, or simply the initials. A comma is preferred by some in place of the colon; and also after the author's first name or initial and the title of the book.[94]

[94] Various other forms are given at length elsewhere; *e. g.*, Hockett, H. C.: *Introduction to Research in American History*, 143-159; Parker, D. D.: *Local History*, 138-141.

Uniformity should be preserved, whatever system is adopted. On the sample bibliographical card, following, UP shows that the number is that of the Library of the University of Pennsylvania:

UP
888
G.FD

Galien, Oeuvres Anatomiques Physiologiques et Médicales de.
(Trans. by C. Daremberg)
2 vols.
Baillière: Paris, 1854-1856.

Periodicals

The exact title of articles in periodicals should be given in quotes (though they may be omitted), the name of the magazine underlined for italics. The volume may be indicated in capital Roman notation, the pages in Arabic figures; if this convention be followed, space and labor may be saved by omitting vol., p., or pp. The month and year should be given after the magazine's title, and may be set off in parenthesis. If the article is a translation, name the translator in parenthesis after the article's title, as in the case of books. If the file of a periodical be rich in pertinent materials, it is desirable to give an item to the file itself, in addition to listing certain items in it. A form-card for an article follows:

UP
913.05
Am3

Gardiner, E. N.
"The Pancration and Wrestling."
Jour. Hellenic Studies (1906) XXVI, 4-22.

If the cards have been made out carefully, only a minor amount of editing will be needed, to make punctuation uniform, before they are put into typescript following the text.

Organization of the Bibliography

The organization of a bibliography should vary somewhat according to the kinds of material it contains. A simple plan, with few subdivisions, is preferable to one minutely subdivided, for this reason: the bibliography is for use; if it has a host of subdivisions, it is almost impossible for a reader to turn with certainty to the correct one to find a particular item, whereas a simple organization will be fixed in mind at once. The general pattern, as a rule, need not be made more elaborate than the following:

BIBLIOGRAPHY

I. Primary Sources

(a) Manuscripts

Hamer, Dr. James, Jr. "An inquiry into the reason wherefore medical men so widely differ in respect to the treatment of certain diseases." 21 pages. (In possesion of Thomas Woody)

Medical diploma, issued to Dr. James Hamer, Jr., by New York University, *pridie Id. Mart.* MDCCCXLIIII. (In possession of Thomas Woody)

(b) Remains

Dental instruments, used by Dr. James Hamer, discovered in an old house, formerly occupied by his daughter, near former Neiffer Post Office, Montgomery Co., Pa. (In possession of Dr. William T. Adelhelm, Upper Darby, Pa.)

(c) Newspapers

New York Weekly Journal, 1733-1749. Incomplete file. (New York Public Library)

Western Herald and Steubenville [O.] *Gazette*, 1819-1820. (State Library, Columbus)

(d) Miscellaneous

Mount Holyoke Female Seminary. Prospectus, 1837. (College Archives)

Soviet Physical Education, Snapshots of, 1929-1930. (In possession of Thomas Woody)

II. Secondary Materials

(a) Books

Forbes, C. A. *Greek Physical Education*. Century: New York, 1929.

(b) Periodical Materials

American Journal of Education, Boston, 1826-1830. 5 vols.; continued as *American Annals of Education and Instruction*, Boston, 1831-1839. 9 vols.

Blaisdell, A. F. "Physical Education of High-School Girls." *N. E. Jour. Educ.* (Sept. 11, 1875) II, 109-110.

Contents, List of Illustrations, and Index Needed

An historical book or paper without a table of contents, list of illustrations or maps, and an index would be like a door without a key. Authors are generally considerate enough to provide a contents and a list of illustrations, but they frequently supply no index, or a poor one. A detailed, analytical table of contents, if it gives the page where each topic or subdivision of a chapter begins, will in some measure unlock the door, but even though such a key is provided, an index is still a necessity.

The Index

In general, it should be said, the only good index is a complete one, including personal and place names and topical entries. Main topics should be analytically presented. Though a separate index of names may be justified, and even more serviceable in some cases, the best rule is to have only one inclusive index, alphabetically arranged.

The best plan for index construction, judged by personal experience, is a card filing system, because of its flexibility. The indexing of works to be printed should only begin when the galleys have been cut into pages. Otherwise, there will be much needless labor, and more opportunity for error. If the manuscript or typescript is to be preserved unpublished, it should be indexed just like a book, if it is to serve users well.

The construction of an index begins with careful, consecutive reading of each page, from beginning to end, listing each name and topic on a separate card as one comes to them. When a name or topic next recurs, a new page entry for it is made on the original card. As the cards are made, they are filed alphabetically, guides being used to facilitate pulling them out as they are wanted for new entries. If occasionally, in case of large books, one may happen to make out a second or third card for the same name or topic, they come together naturally when filed, after the entire text has been read, and their entries are then combined before typing. A simple name-card, with no complexities, will appear thus:

> Atwell, J., 24, 46, 400

Indexing Complex Topics

Indexing subject matter is a more difficult task. Some care is needed in choice of terms, the aim being always to use those which are at once most definitely descriptive of the matter dealt with, and also most likely to occur to a reader who wants to see whether this or that topic appears in the treatise. Some subjects may need to be listed under more than one heading. When all cards have been made out, a close scrutiny should be given such topics, so as to decide in how many ways they should appear. It is common practice, in certain cases, to combine the actual listing of pages under one head, or perhaps two, giving after other headings a cross reference to the rubric where pages may be found. In case of complex topics, analytical subheadings should follow the main one. The card for such an item, in process of growth, might appear as follows:

> Atnletics, 45-150,
> 4 meaning of the term, 47, 49, 52 *f.*,
> 3 Greek, 96-100,
> 2 girls', 104, 109, 112 *ff.*,
> 5 opposition to, 120, 124, 127,
> 1 decline of, 145-50,

If a second card be needed for an extensive item, clip it to the first in the file, combining them later.

Editing Before Final Copy

When the entire text has been read through, the card file must be edited to make sure that punctuation is correct and follows a uniform system. At this reading, the order of the subheads on a complex card may well be indicated conspicuously by placing figures 1, 2, 3, etc., in colored pencil opposite the appropriate items, as shown above, to guide in recopying them. The general coverage item should come first, the others following alphabetically. While entries are still being added, a comma is used to separate figures; when a series has been completed, a semicolon is used to separate it from the series following. No punctuation is required at the very end.

The above complex card, with the order of

items rearranged and properly punctuated, will appear thus:

> Athletics, 45-150; decline of, 145-50; girls', 104, 109, 112 *ff.*; Greek, 96-100; meaning of the term, 47, 49, 52 *f.*; opposition to, 120, 124, 127

> Physical education, I, 60-90; II, 56-205; athletics in, II, 126-30; discipline, as affected by, II, 201, 205; effect of, in colleges, II, 130-33; emphasis on, I, 74, 76, 79 *ff.*; II, 56-9; in higher schools, II, 113-20; in lower schools, II, 110-12; opposition to, I, 63 *f.*, 67; II, 140 *ff.*; teachers of, II, 185-205

Method, in Indexing More Than One Volume

If a work is to appear in two or more volumes, there should be a separate index in each, save the last one, which will contain a combined index of the whole. The second volume may well have many topics which appear in the first; if so, draw a line on the original card, using space above it for items in the first volume, labeled Roman I; and that below it for items in the second, Roman II. Such a card for a complex topic, which has items appearing in both volumes, would appear thus while in process of growth:

> Physical education, I, 60-90,
> 7 opposition to, 63 *f.*, 67,
> 4 emphasis on, 74, 76, 79 *ff.*,
>
> ---
>
> Physical education, II, 56-205,
> 4 emphasis on, 56-9,
> 6 in lower schools, 110-12,
> 5 in higher schools, 113-20,
> 1 athletics in, 126-30,
> 3 effect of, in colleges, 130-33,
> 7 opposition to, 140 *ff.*,
> 8 teachers of, 185-205,
> 2 discipline, as affected by, 201, 205,

When edited for the typist, index figures, placed before each sub-item, as above, will show the order to be followed in recopying; and final commas should be changed to semicolons, to separate the items. All pages referring to a particular phase of the topic in volume I will be collected, and similarly for volume II, as below:

When the whole of the index has been thus edited on the cards, a final copy should be typed in parallel columns on numbered pages, following the bibliography. When in type, it should be restudied once more and compared with the text for possible errors, of omission or commission.

Appendix

Besides the elements of book construction heretofore touched upon, it may be desirable to consider provision of appendices, if certain documents are deemed of such value as to warrant their inclusion, in whole or in part. These, lettered or numbered, should follow the last page of the text.

Preface

Prefaces arose, presumably, as a defense mechanism. In any case, a preface provides the author an opportunity to address to his anticipated audience whatever *apologia* he may feel is necessary, and make acknowledgment of assistance of others, whom he will of course absolve of responsibility for whatever errors he has committed.

Introduction

An introduction is of more moment. In it the author's conception of what he has sought to do, its relation to the larger field of which it is a part, important materials discovered and exploited, particularly significant or novel phases of his methodology, shortcomings seen in retrospect, suggestions useful for further study, and other kindred matters may properly find a place.

Final Steps Before Printing

Assuming that everything has been completed, the author should reread the entire

manuscript as a whole before sending it to the printer or publisher, making sure that uniform practice has been observed in respect to abbreviations, citation usage, punctuation, spelling, capitalization, and the like. Correction of minor points in such matters at this time costs little; later, it will cost much more. Footnotes should be read to the bibliography, and their consecutive numbering through each chapter should be checked. Pagination of the entire volume may well be reviewed; illustrations, if any, need to be definitely assigned to their places in the text, and the list of them checked for accuracy and completeness. It is well, also, to make sure that chapter titles and subheads in the table of contents are in perfect harmony with those that appear throughout the text, and that their pagination is correct.

Proofreading

Mephisto, masquerading as Doctor Faustus in Goethe's immortal drama, advises a student to write diligently "Als dictirt' euch der Heilig' Geist" — "as though the Holy Ghost were dictating." The careful, scientific historian ignores the devil and substitutes documents, writing what they and his critical judgment dictate. Assuming such care and devotion to truth, and that matters have been faithfully written down, it is necessary to practice careful proofreading. Reading of proof is sometimes apt to be associated wholly with examination of the galleys and pages returned by the printer. It is not amiss, surely, to remind authors that proofreading should be equally carefully done each and every time a new copy of anything is made. When one copies a document, the new copy needs to be read back to the original; only thus can a text be kept accurate. Likewise, when the first manuscript draft is recopied or typed, whether it be the manuscript of text, bibliography, or index, the new copy must be closely compared with its predecessor, for deviations may have crept in; and so on with every fresh copy that may be made, including the printer's galleys and page proof.

Assuming that the importance of proofreading is understood, how should it be done? Practice doubtless varies from slight and careless attention to many critical rereadings. One hears of some who read a single proof five times. This may seem a too Herculean labor. On the other hand, no one wants to tremble, as an aged scholar says a close friend of his always did, for fear that on the very first page of his next book some glaring error, due to oversight, would be found. The best safeguard against such mortification lies in proofreading. Perhaps one may express the hope that five readings may not be really necessary, as a general rule; and, at the same time, suggest the wisdom of at least three readings of each proof — first, by two persons reading together, one taking the original, the other the new copy; second, by the author; third, by some person other than the author. These three critical readings should be given to the galleys and to the first page proof. A second page proof is often required, or even a third; but these should be unnecessary, if the manuscript is in first-class condition when given the printer, and if the first proofs have been thoroughly corrected, and the printers have faithfully incorporated all changes. The best result will be gained if authors use conventional printer's marks to indicate corrections to be made.[88] In case of extensive manuscripts, at least, it is desirable, for economy's sake, to use different colored inks so as to differentiate readily betwen author's and printer's errors.

Retrospect and Prospect

One should study the method of history, if he contemplates making a research, just as another scientist will acquaint himself with statistical, experimental, and other methods if he intends to apply himself to areas in which they are indispensable tools. Having acquainted one's self with what others have done to shape and sharpen this tool of the historian, any person may well ask himself: "What is the value of such research, in general; what is the value of the particular study now contemplated? The labor that will be involved is certain to be great. Is it worth the cost?"

Before one enters upon the quest, one should feel convinced of its worth, at least to himself; and he may well have some conviction that its value may transcend mere personal satisfaction. The second, if the work turns out fruitfully, will ultimately outweigh the first consideration, certainly; nevertheless, the sustaining drive will be found rooted in the satisfaction of the personal urge. One of the world's famous satirists remarked, "it's hard not to write satire." Perhaps one should not write history unless he

[88] For an explanation and exemplification of these, see Frank H. Vizetelly, *The Preparation of Manuscripts for the Printer*, 60-65.

feels driven to it, finds it hard not to write history.

As for those who may be inclined to distrust satisfaction of an inner, personal drive as motivation, they may find reassurance in reflecting that the writing of history has been a mark of advancement, a civilizing of the human mind. The more civilized a people becomes, the more the attention given to writing history. Interest in history is a measure of the breadth of human understanding. And if one may be able to add a single bit of sound, well written history to the store of human possessions, the prospect is worth the effort. Temperley calls sound history a sure way to a good immortality; and unsound history an equally certain path to a bad one. Reference to either immortality may well cause mere men to turn back apprehensively, especially if they recall the ancient admonition of the Greeks: "Thou canst not fly to Olympus, nor marry Aphrodite." Still, ignoring affairs Olympian, a mere mortal may clutch his ideal lantern, the Book of Clio, to his breast, remembering Milton: "as well destroy a man as destroy a book, and even better; for to destroy a book is to destroy that living essence of a man which will last forever."

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BOOKS AND WORLD RECOVERY

The desperate and continued need for American publications to serve as tools of physical and intellectual reconstruction abroad has been made vividly apparent by appeals from scholars in many lands. The American Book Center for War Devastated Libraries has been urged to continue meeting this need through 1947. The Book Center is therefore making a renewed appeal for American books and periodicals—for *technical and scholarly books and periodicals in all fields* and particularly for *publications of the past ten years.* We shall especially welcome complete or incomplete files of the JOURNAL OF EDUCATIONAL RESEARCH and the JOURNAL OF EXPERIMENTAL EDUCATION.

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ON DETERMINING THREE DIMENSIONAL REGIONS OF SIGNIFICANCE*

Palmer O. Johnson
University of Minnesota

Cyril Hoyt
University of Chicago

In dealing with the problem of testing certain linear hypotheses, Johnson and Neyman (16) introduced new statistical concept, "the region of significance", which has had a number of applications princi-ally in the field in which the technique was originally applied (1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 5, 17, 21, 22).

As pointed out in (16 p -78), a region of significance is defined by the inequality $S_a^2 \leq \int_\alpha S_r^2$

here $\int_\alpha$ is the value of the likelihood criterion corresponding to a chosen level of significance, α, .e., α = .01, α = .05, etc., and S_a^2 and S_r^2 are the absolute and relative minimum sum of squares, espectively, providing two optimum estimates of the population variance, σ^2, under the conditions rescribed by the properties of the region of significance. These properties are that for certain sys-ems of values of two independent variables, x', y', the hypothesis, $H(X', y')$, should be rejected. This ypothesis in (16) referred to the difference between the best linear estimates of the means of two ran-om samples of observational values. The hypothesis could refer to other statistical functions of ob-ervational data as well. The distinction between this type of hypothesis and the usual null hypothesis ay be made as follows: The usual null hypothesis specifies some fixed set of parameter values esti-ated for the single system of values, say x_1, y_1, provided by the experimental data, and the process of esting the hypothesis consists in setting up a critical region for this specified set of values, x_1, y_1. If he experimental value, or sample point, falls in this critical region, the hypothesis $H(x_1, y_1)$ is rejected nd the generalization usually obtains for the population for which the sample is presumably represent-tive. The Johnson-Neyman technique distinguishes between the systems of values of x' and y' for which he hypothesis $H(X', y')$ should be rejected and the systems for which the hypothesis should be accepted. t thus becomes possible to specify the population in terms of the basic characteristics, x and y, for hich a generalization is permissible. That is, the analysis shows first if there are values of x and y or which, say, the difference in means between two groups is significant. Should such values exist for he variables x, y, they are bounded by a conic section, i.e., an ellipse, parabola, or an hyperbola. Geometrically, then, for two independent variables, the "region of significance" is represented by a onic section. The section can be plotted and the hypothesis $H(X', y')$ represented by any point of this egion should be rejected at the level of significance, α, chosen.

The method of setting up the region of significance for a variable null hypothesis is logically equiva-ent to setting up what might be called a "no confidence" region. That is, if, say, $H(X', y')$ is true then he probability is less than α, that if we draw a sample and determine the region of significance, say, , the region R will contain the sample point. Alternatively, if every time a sample is drawn and the egion R determined we make the statement "For no point, E, of R is $H(X', y')$ true" we may expect to e right about 100 $(1 - \alpha)$ per cent of the time. It should be pointed out, however, that if we draw only ne sample, compute R, take a series of points, $x_1, y_1; x_2, y_2;$ ..... in R, and say "$H(X_1, y_1)$ is false, (X_2, y_2) is false," ..... etc., we cannot say that 100 $(1 - \alpha)$ per cent of these statements will be correct. f an unusual sample had been drawn, we might well be wrong every time.

In this paper the concept of the "region of significance" has been extended to three dimensions. The derivations can, of course, be extended to any number of independent variables. However, the presenta-ion is limited to three independent variables both as an illustration and to obtain specific useful results. The statistical formulation and solution of the problem are presented first, followed by the practical il-lustration in a research problem including the contours used to represent the region of significance in three dimensional space.

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Part I: Mathematical Formulation

Let y represent the value of the experimental character and let u, v, and h represent the values of three other characters of individuals which are assumed to influence both the experimental character, y, and its reaction on conditions say, A and B, whose influence on y is under investigation. The variables u, v, h play the role of independent variables and the experimental character y that of a dependent variable. The values of the experimental character for individuals subject to the conditions A and B are denoted by y' and y'', respectively.

Our basic assumptions may be expressed by saying that the population means of y' and y'' of individuals with fixed values of u, v, and h are some functions (not necessarily the same) of these values u, v, and h, i.e.,

(1) $(y') = f_1 \quad (u, v, h), \qquad (y'') = f_2 \ (u, v, h)$

Our purpose is --

(1) To test the hypotheses, say, H (u', v', h') that for some particular system of fixed values $u = u'$, $v = v'$, and $h = h'$ the two means are equal, or

(2) $f_1 \ (u', v', h') = f_2 \ (u', v', h')$

This, if true, would indicate that the difference in conditions A and B does not affect the average value of the experimental character of individuals in which $u = u'$, $v = v'$, $h = h'$).

The functions f_1 and f_2 are chosen according to the conditions of the particular problem, with the single restriction that both functions f_1 and f_2 must be linear with respect to the unknown parameters they involve.

Here it will be assumed that the polynomials are of the first degree. Thus we write

(3) $(y') = a_1 + b_1 u + c_1 v + d_1 h$

(4) $(y'') = a_2 + b_2 u + c_2 v + d_2 h$

(5) The coefficients $a_1, b_1, c_1, d_1, a_2, b_2, c_2, d_2$ will play the role of these parameters.

The hypothesis, H (u', v', h') to test will be described by one equation

(6) $\theta (u', v', h') = a_1 - a_2 + (b_1 - b_2) u' + (c_1 - c_2) v' + (d_1 - d_2) h' = 0.$

It should be pointed out that it is assumed that, for any fixed values of u, v, h, the distributions of y' and y'' are normal about means (3) and (4) with the same, though unknown variance.

(2) To discriminate between such systems of values, u', v', h' for which the hypothesis $H(u', v', h')$ should be rejected and those for which the hypothesis $H(u', v', h')$ will be accepted. Each system of u', v', and h', (or each hypothesis $H(u', v', h')$) will be represented by a point lying in space with coordinates u', v', h'. Generally it will be possible to specify a region, which is called the region of significance, such that the hypothesis, $H(u', v', h')$ represented by any point of this region should be rejected. This discrimination is made here on the basis of the criterion of likelihood proposed by Neyman and Pearson (19). If we let

(7) $S^2 = \sum_1 (y - a_1 - b_1 u - c_1 v - d_1 h)^2 + \sum_2 (y - a_2 - b_2 u - c_2 v - d_2 h)^2$ where $\sum_1$ and $\sum_2$ represent the summations for the samples subject to the conditions A and B respectively, we can define the criterion of likelihood in the following manner.

(8) $$U = \frac{S_a^2}{S_r^2}$$

where S_a^2 is the minimum value that (7) may assume for any values of (5) and where S_r^2 is the least value that (7) may adopt under the condition that the relation (6) is satisfied. Among others, Kolodziejczyk (18) has demonstrated that S_a^2 is independent of S_b^2 where

(9) $$S_b^2 = S_r^2 - S_a^2$$

He has further shown that if random samples are drawn from the same normal population, the probability distribution of U will be

$$(10) \qquad p(U) = \frac{1}{B\left(\frac{N-S}{2}, \frac{r}{2}\right)} U^{\frac{N-S}{2}} (1-U)^{\frac{r}{2}-1}$$

where S represents the total number of parameters required for specifying the class of admissible hypothes, r represents the number of tthese specified by the hypothesis tested and N represents the total number of observations. In this case s is eight and r is one. The value of U_ε for which

$$(11) \qquad \int_0^{U_\varepsilon} p(U)\, dU = \varepsilon$$

can be obtained by the use of the Incomplete Beta Function table (20). Kolodziejczyk (18) has also shown that if one desires only those percentage points tabled by Fisher (7) in his table of z that the quantities

$$(12) \qquad \frac{S_a^2}{N-s} \quad \text{and} \quad \frac{S_b^2}{r}$$

are those which the latter author considers two independent estimates of the common variance. After one has determined the value of U, say U_o, for a particular set of observational data and the hypothesis to be tested, he then compares it to the value of U_ε obtained from either of the tables mentioned above. If the value of $U_o \leq U_\varepsilon$ the probability of rejecting the hypothesis when it correctly described the conditions under which the observations were made, is less than or equal to ε.

In order to determine the appropriate values that (5) will assume in S_a^2, we consider for the moment that they are continuous variables and differentiate (7) partially with respect to each of these variables. When each of these partial derivatives is set equal to zero we have the familiar systems.

$$(13) \qquad \begin{cases} a_1 n_1 + b_1 \Sigma_1 u + c_1 \Sigma_1 v + d_1 \Sigma_1 h = \Sigma_1 y \\ a_1 \Sigma_1 u + b_1 \Sigma_1 u^2 + c_1 \Sigma_1 uv + d_1 \Sigma_1 uh = \Sigma_1 uy \\ a_1 \Sigma_1 v + b_1 \Sigma_1 vu + c_1 \Sigma_1 v^2 + d_1 \Sigma_1 vh = \Sigma_1 vy \\ a_1 \Sigma_1 h + b_1 \Sigma_1 hu + c_1 \Sigma_1 hv + d_1 \Sigma_1 h^2 = \Sigma_1 hy \end{cases}$$

$$(14) \qquad \begin{cases} a_2 n_2 + b_2 \Sigma_2 u + c_2 \Sigma_2 v + d_2 \Sigma_2 h = \Sigma_2 y \\ a_2 \Sigma_2 u + b_2 \Sigma_2 u^2 + c_2 \Sigma_2 uv + d_2 \Sigma_2 uh = \Sigma_2 uy \\ a_2 \Sigma_2 v + b_2 \Sigma_2 vu + c_2 \Sigma_2 v^2 + d_2 \Sigma_2 vh = \Sigma_2 vy \\ a_2 \Sigma_2 h + b_2 \Sigma_2 hu + c_2 \Sigma_2 hv + d_2 \Sigma_2 h^2 = \Sigma_2 hy \end{cases}$$

Denote the values of (5) determined by solving (13) and (14) by

$$(15) \qquad a_1^\circ, b_1^\circ, c_1^\circ, d_1^\circ, a_2^\circ, b_2^\circ, c_2^\circ, d_2^\circ,$$

in terms of these we have

$$(16) \qquad \begin{aligned} S_a^2 = {} & \Sigma_1 y^2 - a_1^\circ \Sigma_1 y - b_1^\circ \Sigma_1 uy - c_1^\circ \Sigma_1 vy - d_1^\circ \Sigma_1 hy \\ & + \Sigma_2 y^2 - a_2^\circ \Sigma_2 y - b_2^\circ \Sigma_2 uy - c_2^\circ \Sigma_2 vy - d_2^\circ \Sigma_2 hy \end{aligned}$$

In order to determine the values that (5) will assume in S_r^2, that is, under the condition that relation (6) is satisfied, we minimize

$$(17) \qquad \phi = S^2 - 2\alpha \left\{ (a_1 + b_1 u' + c_1 v' + d_1 h') - (a_2 + b_2 u' + c_2 v' + d_2 h') \right\}$$

where α is an undetermined multiplier, the value of which we shall determine later. If we regard u', v', and h' as fixed and (5) as continuous variables, we then differentiate ϕ partially with respect to each of these variables. When each of these partial derivatives is set equal to zero we obtain the following systems.

$$(18) \qquad \begin{cases} a_1 n_1 + b_1 \Sigma_1 u + c_1 \Sigma_1 v + d_1 \Sigma_1 h = \Sigma_1 y + \alpha \\ a_1 \Sigma_1 u + b_1 \Sigma_1 u^2 + c_1 \Sigma_1 uv + d_1 \Sigma_1 uh = \Sigma_1 uy + \alpha u' \\ a_1 \Sigma_1 v + b_1 \Sigma_1 vu + c_1 \Sigma_1 v^2 + d_1 \Sigma_1 vh = \Sigma_1 vy + \alpha v' \\ a_1 \Sigma_1 h + b_1 \Sigma_1 hu + c_1 \Sigma_1 hv + d_1 \Sigma_1 h^2 = \Sigma_1 hy + \alpha h' \end{cases}$$

$$(19) \qquad \begin{cases} a_2 n_2 + b_2 \Sigma_2 u + c_2 \Sigma_2 v + d_2 \Sigma_2 h = \Sigma_2 y - \alpha \\ a_2 \Sigma_2 u + b_2 \Sigma_2 u^2 + c_2 \Sigma_2 uv + d_2 \Sigma_2 uh = \Sigma_2 uy - \alpha u' \\ a_2 \Sigma_2 v + b_2 \Sigma_2 vu + c_2 \Sigma_2 v^2 + d_2 \Sigma_2 vh = \Sigma_2 vy - \alpha v' \\ a_2 \Sigma_2 h + b_2 \Sigma_2 hu + c_2 \Sigma_2 hv + d_2 \Sigma_2 h^2 = \Sigma_2 hy - \alpha h' \end{cases}$$

Denote the values of (5) determined by solving (18) and (19) by

(20) $\quad a_1', b_1', c_1', d_1', a_2', b_2', c_2', d_2'$

Then S_r^2 may be written as

(21) $$S_r^2 = \Sigma_1 y^2 - a_1'\Sigma_1 y - b_1'\Sigma_1 uy - c_1'\Sigma_1 vy - d_1'\Sigma_1 hy + \Sigma_2 y^2 - a_2'\Sigma_2 y - b_2'\Sigma_2 uy - c_2'\Sigma_2 vy - d_2'\Sigma_2 hy$$

The relation between S_α^2 and S_r^2 can be obtained in terms of determinants as shown in the following paragraphs. Let the determinant

(22) $$D = \begin{vmatrix} \Sigma_1 y^2 & \Sigma_1 y & \Sigma_1 uy & \Sigma_1 vy & \Sigma_1 hy \\ \Sigma_1 y & n_1 & \Sigma_1 u & \Sigma_1 v & \Sigma_1 h \\ \Sigma_1 uy & \Sigma_1 u & \Sigma_1 u^2 & \Sigma_1 uv & \Sigma_1 uh \\ \Sigma_1 vy & \Sigma_1 v & \Sigma_1 vu & \Sigma_1 v^2 & \Sigma_1 vh \\ \Sigma_1 hy & \Sigma_1 h & \Sigma_1 hu & \Sigma_1 hv & \Sigma_1 h^2 \end{vmatrix}$$

(23) and let D' denote the determinant with the similar elements except that n_1 is replaced by n_2 and the sums are taken for the sample subject to the conditions B. Let D_{ij} and D'_{ij} represent the cofactors of the j-th element in the i-th row for the determinants (22) and (23). Then

(24) $$a_1^\circ = -\frac{D_{12}}{D_{11}}\ ;\ b_1^\circ = -\frac{D_{13}}{D_{11}}\ ;\ c_1^\circ = -\frac{D_{14}}{D_{11}}\ ;\ d_1^\circ = -\frac{D_{15}}{D_{11}}$$

(25) $$a_2^\circ = -\frac{D'_{12}}{D_{11}}\ ;\ b_2^\circ = -\frac{D'_{13}}{D_{11}}\ ;\ c_2^\circ = -\frac{D'_{14}}{D_{11}}\ ;\ d_2^\circ = -\frac{D'_{15}}{D_{11}}$$

Substituting these values in (16) gives

(26) $$S_\alpha^2 = \frac{1}{D_{11}}\left\{D_{11}\Sigma_1 y^2 + D_{12}\Sigma_1 y + D_{13}\Sigma_1 uy + D_{14}\Sigma_1 vy + D_{15}\Sigma_1 hy\right\} + \frac{1}{D_{11}}\left\{D'_{11}\Sigma_2 y^2 + D'_{12}\Sigma_2 y + D'_{13}\Sigma_2 uy + D'_{14}\Sigma_2 vy + D'_{15}\Sigma_2 hy\right\}$$

which is equivalent to

(27) $$S_\alpha^2 = \frac{D}{D_{11}} + \frac{D'}{D_{11}}$$

Let

(28) $$R = \begin{vmatrix} 0 & 1 & u' & v' & h' \\ 1 & n_1 & \Sigma_1 u & \Sigma_1 v & \Sigma_1 h \\ u' & \Sigma_1 u & \Sigma_1 u^2 & \Sigma_1 uv & \Sigma_1 uh \\ v' & \Sigma_1 v & \Sigma_1 vu & \Sigma_1 v^2 & \Sigma_1 vh \\ h' & \Sigma_1 h & \Sigma_1 hu & \Sigma_1 hv & \Sigma_1 h \end{vmatrix}$$

(29) and let R' represent the determinant whose elements are the corresponding sums for the sample subject to the conditions B. Let R_{ij} and R'_{ij} represent the cofactors of the j-th element in the i-th row for the determinants (28) and (29). Comparison with (22) and (23) reveals that $R_{11} = D_{11}$ and $R'_{11} = D'_{11}$. In terms of these cofactors the solution of (18) and (19) may be written as

(30) $$a_1' = -\frac{D_{12}+\alpha R_{12}}{D_{11}}\ ;\ b_1' = -\frac{D_{13}+\alpha R_{13}}{D_{11}}\ ;\ c_1' = -\frac{D_{14}+\alpha R_{14}}{D_{11}}\ ;\ d_1' = -\frac{D_{15}+\alpha R_{15}}{D_{11}}$$

(31) $$a_2' = -\frac{D'_{12}+\alpha R'_{12}}{D'_{11}}\ ;\ b_2' = -\frac{D'_{13}+\alpha R'_{13}}{D'_{11}}\ ;\ c_2' = -\frac{D'_{14}+\alpha R'_{14}}{D'_{11}}\ ;\ d_2' = -\frac{D'_{15}+\alpha R'_{15}}{D'_{11}}$$

Comparison with (24) and (25) reveals that

(32) $$a_1' = a_1^\circ - \frac{\alpha R_{12}}{D_{11}}\ ;\ b_1' = b_1^\circ - \frac{\alpha R_{13}}{D_{11}}\ ;\ c_1' = c_1^\circ - \frac{\alpha R_{14}}{D_{11}}\ ;\ d_1' = d_1^\circ - \frac{\alpha R_{15}}{D_{11}}$$

(33) $$a_2' = a_2^\circ - \frac{\alpha R'_{12}}{D'_{11}}\ ;\ b_2' = b_2^\circ - \frac{\alpha R'_{13}}{D'_{11}}\ ;\ c_2' = c_2^\circ - \frac{\alpha R'_{14}}{D'_{11}}\ ;\ d_2' = d_2^\circ - \frac{\alpha R'_{15}}{D'_{11}}$$

Substituting these values in (21) gives

(34) $$S_r^2 = S_\alpha^2 + \frac{\alpha}{D_{11}}\left\{R_{12}\Sigma_1 y + R_{13}\Sigma_1 uy + R_{14}\Sigma_1 vy + R_{15}\Sigma_1 hy\right\} - \frac{\alpha}{D_{11}}\left\{R'_{12}\Sigma_2 y + R'_{13}\Sigma_2 uy + R'_{14}\Sigma_2 vy + R_{15}\Sigma_2 hy\right\}$$

It can be shown that

(35) $$R_{12}\Sigma_1 y + R_{13}\Sigma_1 uy + R_{14}\Sigma_1 vy + R_{15}\Sigma_1 hy = D_{12} + D_{13}u' + D_{14}v' + D_{15}h'$$

in the following manner. Denote the cofactor $D_{11} = R_{11}$ by A and let A_{1j} represent the cofactor of the j-th element in the i-th row of this new determinant. Then

(36) $R_{12} = -A_{11} - u'A_{21} - v'A_{31} - h'A_{41}$

(37) $R_{13} = -A_{12} - u'A_{22} - v'A_{32} - h'A_{42}$

(38) $R_{14} = -A_{13} - u'A_{23} - v'A_{33} - h'A_{43}$

(39) $R_{15} = -A_{14} - u'A_{24} - v'A_{34} - h'A_{44}$

If we multiply (36) by Σ_1 y, (37) by Σ_1 uy, (38) by Σ_1 vy, (39) by Σ_1 hy and add we obtain the relation (35) since $A_{ij} = A_{ji}$. Similarly it can be shown that

(40) $R'_{11}\Sigma_2 y + R'_{12}\Sigma_2 uy + R'_{13}\Sigma_2 vy + R'_{14}\Sigma_2 hy = D'_{11} + D'_{12}u' + D'_{13}v' + D'_{14}h'$

Making use of the relations (35) and (40), (34) yields

(41) $S_r^2 = S_a^2 + \frac{\alpha}{D_{11}}\left(D_{12} + D_{13}u' + D_{14}v' + D_{15}h'\right) - \frac{c}{D_{11}}\left(D'_{11} + D'_{12}u' + D'_{13}v' + D'_{14}h'\right)$

If we consider the relations (24) and (25), (41) may be written as

(42) $S_r^2 = S_a^2 - \alpha\left\{(a_1^\circ + b_1^\circ u' + c_1^\circ v' + d_1^\circ h') - (a_2^\circ + b_2^\circ u' + c_2^\circ v' + d_2^\circ h')\right\}$

In order to evaluate α explicitly in terms of previously defined quantities, we notice from (32) that

(43) $(a_1' - a_1^\circ) + (b_1' - b_1^\circ)u' + (c_1' - c_1^\circ)v' + (d_1' - d_1^\circ)h' =$
$= -\frac{\alpha}{R_{11}}\left[R_{12} + R_{13}u' + R_{14}v' + R_{15}h'\right]$ or $-\frac{\alpha}{R_{11}}R$

and from (33) that

(44) $(a_2' - a_2^\circ) + (b_2' - b_2^\circ)u' + (c_2' - c_2^\circ)v' + (d_2' - d_2^\circ)h' =$
$= \frac{\alpha}{R'_{11}}\left[R'_{12} + R'_{13}u' + R'_{14}v' + R'_{15}h'\right]$ or $\frac{\alpha}{R'_{11}}R$

(45) If we denote $-\frac{R}{R_{11}}$ by P and $-\frac{R'}{R'_{11}}$ by Q we have

(46) $\alpha(P + Q) = (a_1' - a_1^\circ) + (b_1' - b_1^\circ)u' + (c_1' - c_1^\circ)v' + (d_1' - d_1^\circ)h'$
$- (a_2' - a_2^\circ) - (b_2' - b_2^\circ)u' - (c_2' - c_2^\circ)v' - (d_2' - d_2^\circ)h'$

Since the first line of the right member of (47) was assumed, by the hypothesis, to be zero,

(48) $\alpha = -\frac{(a_1^\circ - a_2^\circ) + (b_1^\circ - b_2^\circ)u' + (c_1^\circ - c_2^\circ)v' + (d_1^\circ - d_2^\circ)h'}{P + Q}$

If we denote the numerator of this fraction by $D(u', v', h')$ (48) becomes

(49) $\alpha = -\frac{D(u', v', h')}{P + Q}$

Likewise (42) may be written as

(50) $S_r^2 = S_a^2 - \alpha\left\{D(u', v', h')\right\}$

Eliminating α from (49) and (50), we have

(51) $S_r^2 = S_a^2 + \frac{\{D(u', v', h')\}^2}{P + Q}$

The region of significance is defined as that portion of u, v, h space for which the following inequality is satisfied.

(52) $\frac{S_a^2}{S_r^2} \geq U_\epsilon$ or $U_\epsilon S_r^2 - S_a^2 \geq 0$

This region is bounded by the surface

(53) $U_\epsilon S_r^2 - S_a^2 = 0$

which becomes

(54) $\frac{U_\epsilon}{1 - U_\epsilon}\left\{D(u', v', h')\right\}^2 - (P + Q)S_a^2 = 0$

If we consider the relations (51) and (53). If the constant $\frac{U_\epsilon}{1 - U_\epsilon}$ is denoted by w, (54) may be written as

$$(55)\quad w\left\{D(u', v', h')\right\}^2 - (P + Q)S_a^2 = 0$$

In practice the solution of system (13) can be carried on simultaneously with that of (18). This process yields the following relations

$$(56)\qquad \begin{aligned} a_1' &= a_1^\circ + \alpha\,(k_{11} + l_{11}u' + m_{11}v' + n_{11}h') \\ b_1' &= b_1^\circ + \alpha\,(k_{12} + l_{12}u' + m_{12}v' + n_{12}h') \\ c_1' &= c_1^\circ + \alpha\,(k_{13} + l_{13}u' + m_{13}v' + n_{13}h') \\ d_1' &= d_1^\circ + \alpha\,(k_{14} + l_{14}u' + m_{14}v' + n_{14}h') \end{aligned}$$

Likewise the simultaneous solution of (14) and (19) yields the following relations

$$(57)\qquad \begin{aligned} a_2' &= a_2^\circ - \alpha\,(k_{21} + l_{21}u' + m_{21}v' + n_{21}h') \\ b_2' &= b_2^\circ - \alpha\,(k_{22} + l_{22}u' + m_{22}v' + n_{22}h') \\ c_2' &= c_2^\circ - \alpha\,(k_{23} + l_{23}u' + m_{23}v' + n_{23}h') \\ d_2' &= d_2^\circ - \alpha\,(k_{24} + l_{24}u' + m_{24}v' + n_{24}h') \end{aligned}$$

where the k's, l's, m's, and n's are constants.

From (56) we have that

$$(a_1' - a_1^\circ) + (b_1' - b_1^\circ)u' + (c_1' - c_1^\circ)v' + (d_1' - d_1^\circ)h'$$

$$(58)\qquad = \alpha\begin{cases} (k_{11} + l_{11}u' + m_{11}v' + n_{11}h') \\ + (k_{12} + l_{12}u' + m_{12}v' + n_{12}h')u' \\ + (k_{13} + l_{13}u' + m_{13}v' + n_{13}h')v' \\ + (k_{14} + l_{14}u' + m_{14}v' + n_{14}h')h' \end{cases}$$

The quantity in the left member of (58) was previously (43) defined as αP. Hence (56) and (58) give a means for computing P without the use of determinants. Similarly, from (57)

$$(a_2' - a_2^\circ) + (b_2' - b_2^\circ)u' + (c_2' - c_2^\circ)v' + (d_2' - d_2^\circ)h'$$

$$(59)\qquad = \alpha\begin{cases} (k_{21} + l_{21}u' + m_{21}v' + n_{21}h') \\ + (k_{22} + l_{22}u' + m_{22}v' + n_{22}h')u' \\ + (k_{23} + l_{23}u' + m_{23}v' + n_{23}h')v' \\ + (k_{24} + l_{24}u' + m_{24}v' + n_{24}h')h' \end{cases}$$

According to (44) the quantity in the left member of (59) was defined as $-\alpha Q$.

Part II: Practical Application

An application of the preceding formulation is given below. The investigation was directed at determining the difference in achievement between two groups of college students undergoing instruction in two different types of courses in general physics. There are three criteria for determining the relative abilities of the two groups, each of which has been shown to bear a relationship to achievement, (1) score on the American Council on Education Psychological Examination, (2) proficiency in elementary mathematics, (3) honor-point ratio. The measure of achievement consisted of the score on the Mechanics section of the Cooperative Physics Test for College Students. The data were collected during the academic year of 1940-41 in the University of Minnesota. The foregoing scores were obtained for 111 students in the first course, Physics 1, and for 257 in the other, Physics 7.

Table I contains the summary statistics for these two groups while Table II contains the quantities (15) which gives (7) its absolute minimum value. Substituting these values (15) in (16) gives $S_a^2 = 13,258.38$. Table III contains the values of the constants, the k's, l's, m's and n's of formulas (56) and (57). From these P and Q are computed according to (58) and (59), then multiplied by S_a^2 to give

Table I
Summary Statistics for Physics 1 and Physics 7

	Physics 1	Physics 7
N - the number of students	111	257
Σ y achievement test score	1,324	6,783
Σy^2	19,862	194,001
Σ u psychological test score	9,728	23,746
Σ v mathematics test score	3,450	14,411
Σ h honor point ratio	1,286	3,261
Σu^2	905,694	2,338,412
Σv^2	118,846	823,945
Σh^2	20,084	53,417
Σ uy	118,635	645,402
Σ vy	44,200	386,261
Σ hy	17,532	92,843
Σ uv	307,220	1,349,410
Σ uh	117,560	319,746
Σ vh	42,408	191,223

Table II
Regression Coefficients

$a_1^* = 2.01554247$	$a_2^* = 10.26490910$
$b_1^* = .00103309$	$b_2^* = .06771814$
$c_1^* = .19246053$	$c_2^* = .08561873$
$d_1^* = .33144215$	$d_2^* = .39956522$

Table III

Inverse Matrices*

$k_{11} = +.20122307$	$l_{11} = -.00146961$	$m_{11} = -.00208607$	$n_{11} = +.00012250$
$k_{12} = -.00146961$	$l_{12} = +.00002085$	$m_{12} = -.00000514$	$n_{12} = -.00001711$
$k_{13} = -.00208607$	$l_{13} = -.00000514$	$m_{13} = +.00009678$	$n_{13} = -.00004069$
$k_{14} = +.00012250$	$l_{14} = -.00001711$	$m_{14} = -.00004069$	$n_{14} = +.00022802$
$k_{21} = +.26071669$	$l_{21} = -.00043274$	$m_{21} = -.00448355$	$n_{21} = +.00272429$
$k_{22} = -.00043274$	$l_{22} = +.00000881$	$m_{22} = -.00000444$	$n_{22} = -.00001040$
$k_{23} = -.00448355$	$l_{23} = -.00000444$	$m_{23} = +.00010173$	$n_{23} = -.00006389$
$k_{24} = +.00272429$	$l_{24} = -.00001040$	$m_{24} = -.00006389$	$n_{24} = +.00014339$

*See formulas (56) and (57)

(60) $S_a^2 (P + Q) = .39323725\, u' + 2.63185711\, v'^2 + 4.92434901\, h'^2 - .25399077\, u'v' - .72960070\, u'h' - 2.77303937\, v'h' - 50.44400724\, u' - 174.20505274\, v' + 75.48770951\, h' + 6124.57287519$

Next, the value of $D(u', v', h')$ is determined according to the numerator of the right member of (48). This is found to be

(61) $D(u', v', h') = -8.2493666 - .066850\, u' + .1068418\, v' - .0681230\, h'$

Hence

(62) $\left[D(u', v', h')\right]^2 = .00446892\, u'^2 + .01141517\, v'^2 + .00464074\, h'^2 - .01428475\, u'v' + .00910805\, u'h' - .01455677\, v'h' + 1.10294031\, u' - 1.76275435\, v' + 1.12394320\, h' + 68.05204930$

In this case* the 5% level of significance is used for determining the constant w used in equation (55) whose locus is the surface bounding the "region of significance". By interpolation in Johnson and Neyman's Table (13) $\mathcal{U}$ (5%) of formula (11) is found to be .9893 and w = 93.047. We are now in a position to write explicitly the equation of the boundary surface. If we represent the left hand member of (55) by ψ (u′, v′, h′), this yields

$$\begin{aligned}(63)\quad \psi\,(u', v', h') = {} & .02258235\,u'^2 - 1.56970979\,v'^2 - 4.49254208\,h'^2 \\ & - 1.07516236\,u'v' + 1.57707743\,u'h' + 1.41857559\,v'h' \\ & + 153.06929333\,u' + 10.18604408\,v' + 29.09183342\,h' \\ & + 207.46612811\end{aligned}$$

Dividing (63) by the coefficient of u'^2 yields the following equation of the surface

$$\begin{aligned}(64)\quad & u'^2 - 69.510472\,v'^2 - 198.940416\,h'^2 - 47.610740\,u'v' + 69.836726\,u'h' \\ & + 62.817891\,v'h' + 6778.2711\,u' + 451.062179\,v' + 1288.2553\,h' \\ & + 9,187.0921 = 0\end{aligned}$$

The center of this region is found to be

$$-32.176574,\quad +83.53885,\quad -276.9091$$

The equation of the surface referred to its center as origin is

$$\begin{aligned}(65)\quad & u'^2 - 69.510472\,v'^2 - 198.940416\,h'^2 - 47.610740\,u'v' + 69.836726\,u'h' \\ & + 62.817891\,v'h' - 931,180.6048 = 0\end{aligned}$$

The method used here to represent this three-dimensional "region of significance" is to plot contours at several representative "levels" of the variable h which in this case is ten times the honor point ratio. The first contour plotted corresponds to h′ = 40 which is 7.823426 when referred to the original origin and hence represents an approximate honor point ratio of .78. The equation of this contour is:

$$(66)\quad u'^2 - 69.510472\,v'^2 - 47.610740\,u'v' + 2,793.4690\,u' + 2,512.7156\,v' - 1,259,085.2608 = 0$$

This equation is translated to its center as origin, where the center is - 105.5941, 54.23736. Then the equation of the contour is

$$(67)\quad u''^2 - 69.510472\,v''^2 - 47.610740\,u''v'' - 1,338,431 = 0$$

Next the axes are rotated through the angle whose tangent is λ in order to eliminate the u″v″ term.** That is: the equation of the new u′ axis is $u = \lambda u''$ and the new v′ axis is $v' = -\frac{1}{\lambda} u''$ where λ is the positive root of

$$(68)\quad h\lambda^2 + (a-b)\lambda - h = 0$$

where a, b and 2h represent the coefficients of u''^2, v''^2 and u″v″, respectively.** In this case $\lambda = 3.267958$. If A and B are used to represent the coefficients of u^2 and v^2 respectively when referred to these rotated axes, the following relations hold:

$$(69)\quad A + B = a + b$$

$$(70)\quad AB = ab - h^2$$

From these we find A = - 76.79494 and B = 8.28447 so the equation of this contour becomes

$$(71)\quad -76.79494\,u^2 + 8.28448\,v^2 - 1,338,431 = 0$$

The locus of this equation is shown in solid black in Figure 1. Contours corresponding to honor point ratios of 2.78 and 1.78 are plotted in dashes of uniform length for the former and in alternating long and short dashes for the latter. The center of the latter is - 131.9926, 67.7967 while that of the former is - 158.3921, 81.3560. The value of λ is the same for each of these as in the preceding case. The equations of these two contours when referred to the rotated axes are:

*Although this choice of the level of significance is entirely arbitrary on the part of the investigator, in any specific example the locus of (55) may be imaginary. In this instance S_r^2 was computed according to formula (21) and found to be 13,400 so that (8) yielded the value .989.

**See plane analytic geometry text such as Fine and Thompson (8) for this manner of carrying out a rotation of axes.

(72) $-76.79494\,u^2 + 8.28448\,v^2 - 1{,}625{,}895 = 0$

(73) $-76.794947\,u^2 + 8.28448\,v^2 - 1{,}552{,}509 = 0$

respectively.

A plane section cutting the three-dimensioned region at the level where the honor point ratio is .78 is shown in Figure 2. The dots represent individuals in the Physics 7 class who had honor point ratios between .28 and 1.27 and the small x's represent members of the Physics 1 class with the same range of honor point ratios. The interpretation to be given to this plane section of the three dimensioned region of significance is that for all systems of values of u′, v′, and h′ falling in this region the data would be sufficient for the rejection of the hypothesis, H(u′, v′, h′) stating that $\theta(u', v', h') = 0$. Specifically, in this case, the mean final scores of the Physics 7 class on the Mechanics section of the Cooperative Test for College Students may be expected to be higher than the mean scores of the Physics 1 class for all systems of values of psychological test scores (u′), mathematical test scores (v′), and honor point ratios (h′) (in this case with an average honor point ratio of .78, for individual values ranging from .28 to 1.27) falling within the region of significance.

Figure 3 is a similar plane section corresponding to an honor point ratio of 1.78 with observational values in the range from 1.28 to 2.27. The interpretation is similar to that for Figure 2. Only 24 cases occupied positions above the plane section depicted in Figure 3 and 31 were below the section shown in Figure 2. Corresponding figures for this small number of cases are not reproduced here.

The three dimensional region of significance, or conicoid, may be an ellipsoid, a paraboloid, or an hyperboloid. In the interesting case of the hyperboloid, we reject the hypothesis, H(u′, v′, h′) stating that $\theta(u', v', h') = 0$ in favor of the alternative hypothesis, sometimes assuming that $\theta(u', v', h')$ is positive and sometimes that it is negative in accordance with the sign of D (u′, v′, h′), that is, the region of significance would consist of two parts determining values of u′, v′, h′ for which alternatively the one or the other of the two groups under comparison may be said to be superior with respect to the criterion of comparison used.

It should be pointed out that the method developed here while applied to a problem in educational psychology could likely find a number of useful applications in science, particularly in agriculture, in biology, and in industry.

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SAMPLE PLAN FOR A SURVEY OF HIGHER EDUCATION ENROLLMENT

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This is a description of an application of stratified-random sampling in a survey of higher educational enrollments. The survey was conducted by the U.S. Office of Education in October of 1946 and reported in Statistical Circular, SRS-21.3-116, Higher Education Enrollment: Fall 1946, November 20, 1946, (mimeographed). The basic plan of the sample design has been found useful for enumeration in various types of finite populations [1], though there appears to be no published evidence of its previous application in surveys of school populations.

The plan used has several advantages over the "complete coverage" survey, and most particularly over the "incomplete complete coverage" survey, as that type of survey often becomes. The first is economy due to greatly reduced work-load. Among others are speed, accuracy, and definite advance knowledge of reliability.

Not only has this survey demonstrated the value of carefully planned sampling, but also it has proven the value of (a) utilizing information already at hand about a universe, where that information is available, and (b) utilizing techniques which produce desired reliability and, at the same time, minimize the number of returns required in the sample.

The purpose of the survey was to secure unbiased estimates of total enrollments of various types of students in each of six major classes of higher educational institutions. Estimates of total enrollment of all students were to have coefficients of variation of .05 for each of the six classes.

Type of Estimates Used

A modified stratified-random design was used. Institutions listed in the Office of Education files or the latest directory defined the population. For most of the 1,749 institutions filed, there was also 1941-42 and 1943 fall enrollments from biennial surveys of higher education for those years.

Estimates for each class of institution were computed as follows:

$$\hat{S} = \sum_{i=1}^{L} \frac{N_i}{n_i} \sum_{j=1}^{n_i} x_{ij} \qquad \text{.....(1)}$$

Where S is the estimated total enrollment of all institutions in all L strata of a particular class of institution, N_i is the total number of institutions in the ith stratum, n_i the number in the sample from the ith stratum, and x_{ij} is the enrollment of the jth institution in the ith stratum.

Stratification

The first step in designing the sample was grouping the 1,749 institutions into eight type categories. The six categories of institutions to be used in the final report were the basis for this classification. For survey purposes, however, universities and junior colleges were split into two groups, each on the basis of source of control, public or private, thus producing the eight type categories as follows:

Type of institution	Number of Institutions	
	Total (N)	In sample (n)
a. Publicly controlled universities and large institutions of complex organization	69	23
b. Privately controlled universities and large institutions of complex organization	62	20
c. Colleges of arts and sciences	557	53
d. Independent technical and professional schools	287	72
e. Teachers colleges and normal schools	201	57
f. Publicly controlled junior colleges	246	30

[1] See theory in reference (3) by Hansen and Hurwitz, and report of application in reference (2) by Deming and Simmons. Dr. Deming and Mr. Simmons were both of material assistance in the planning and execution of the survey reported here.

g. Privately controlled junior colleges	222	47
h. Negro institutions	105	31
All institutions	1,749	333

Each of the eight type categories was divided into five size strata, having approximately equal 1941-42 enrollemnt. For each type category in which there were institutions enrolling women only or men only separate strata were established for such institutions. In categories in which there were institutions from which no 1941-42 statistics had been received, there was an eighth stratum for such institutions.

For example, the 201 teachers colleges and normal schools were stratified as follows:

Group	Number of institutions
e-1 (largest)	13
e-2	18
e-3	26
e-4	42
e-5 (smallest)	73
e-6 (women only)	24
e-8 (no enrollment data)	5
All groups	201

The first five strata are based on size, the 13 largest institutions (1941-42 enrollment) in group e-1, the 73 smallest in group e-5, etc. Group e-6 is made up of the 24 institutions which had no men students enrolled in either 1941-42 or the fall of 1943. The last stratum consisted of all institutions for which useable statistics were not available for classification otherwise.

Determining the Number of Cases Required

Where $\sigma_i^2 = \frac{1}{N_i} \sum_{i=1}^{N_i} (x_{ij} - \bar{x}_i)^2$ is the standard deviation of enrollments of institutions in the ith stratum for any date, the variance of the estimate in (1) is

$$\sigma_s^2 = \sum_{i=1}^{L} \left(\frac{N_i^2 \sigma_i^2}{n_i} - \frac{N_i - n_i}{N_i - 1} \right) \qquad \text{.....(2)}$$

$$= \sum_{i=1}^{L} \frac{N_i^2 \sigma_i^2}{n_i} - \sum_{i=1}^{L} N_i \sigma_i^2 \qquad \text{.....(3)}$$

It is important to note that these formulas require the standard deviation, or variance, of the population, not that obtained from a sample. In the present case almost complete knowledge of population variances was at hand, where not, it was estimated. Actually the analysis of 1941-42 and 1943 data was useful only as a means of approximating characteristics of the desired population, namely, enrollment of institutions in 1946. This assumed high correlations between 1946 enrollments and enrollments for the earlier years. As will be seen, such approximations were useful in this survey in reducing the number of cases required to meet the desired reliability.

According to the principle of optimum allocation [2], the fewest cases will be required to yield a given level of reliability if they are distributed among strata in proportion to $N_i \sigma_i$. That is,

$$\frac{n_i}{n} = \frac{N_i \sigma_i}{\sum_{i=1}^{L} N_i \sigma_i} \qquad \text{.....(4)}$$

$$\text{or} \qquad n_i = \frac{N_i \sigma_i}{\sum N_i \sigma_i} \cdot n \qquad \text{.....(5)}$$

where n is the number of institutions in all strata in the class, i.e., $n = \sum_{i=1}^{L} n_i$.

The formula for determining n is easily derived from (3) and (5):

$$n = \frac{\left(\sum_{i=1}^{L} N_i \sigma_i \right)^2}{\sigma_s^2 + \sum_{i=1}^{L} N_i \sigma_i^2} \qquad \text{.....(6)}$$

In this survey the standard error was not set. Instead the coefficient of variation was set as follows:

$$C.V. = \sigma_{\bar{x}} / \bar{S} = .05$$

Hence (6) above was applied in the following form:

$$n = \frac{\left(\sum_{i=1}^{L} N_i \sigma_i\right)^2}{.002\text{-}5\,\bar{S}^2 + \sum_{i=1}^{L} N_i \sigma_i^2} \qquad \text{.....(7)}$$

Though the stratification was based upon 1941-42 enrollment, the allocation using equations (5) and (7) was based upon enrollments in the fall of 1943. The reason for this was to make allowances for changes in variances within strata from year to year. By the method of stratification, strata were very homogeneous as to 1941-42 enrollment. Slightly higher relative variances would be expected in the fall of 1946 to the extent that 1941-42 and 1946 enrollments did not correlate perfectly. It was assumed that the magnitude of relative variances of 1943 data would be more like those for 1946 data for institutions grouped into 1941-42 size strata. This assumption proved to be correct.

In table I are standard deviations and coefficients of variation for the five size strata of teachers colleges and normal schools. Since they were stratified according to 1941-42 enrollment, the coefficients are low for that year. The impact of wartime reductions in enrollment was variable. As may be expected, therefore, the coefficients for the fall of 1943 were higher, and in magnitude more like those actually found for the survey year 1946, even though the prewar return to large enrollments was made with much more uniformity within some strata, particularly e-2, and e-3, than in others, particularly e-1. The standard deviation of the largest stratum, e-1, tripled between 1943 and 1946 as enrollments increased by 150 percent. In contrast, in stratum e-2 enrollments were three times as great in 1946 as in 1943, but the standard deviation increased only from 190 to 251.

An examination of the sets of coefficients of variation for the three periods in table I will show how greatly the 1946 situation would have been underestimated using 1941-42 variances, and that this was in part corrected by using variances of the 1943 enrollment data.

Allocation Procedure Illustrated

The allocation procedure will be illustrated, again using the 201 teachers colleges and normal schools. The 1943 fall total enrollment for the 201 institutions, S, was 56,472. In table II are other data needed to solve equation (7).

$$n = \frac{715{,}830{,}025}{.0025 \times 56{,}472^2 + 4{,}638{,}948} = \frac{715{,}830{,}025}{7{,}974{,}976 + 4{,}638{,}948} = 56.7$$

This number is distributed according to (5) by means of the $N_i \sigma_i$ values of strata (column 5 of table II). The result, after rounding to whole numbers, appears in column 7 of table II.

Table I

COMPARISON OF STRATA VARIANCES IN ENROLLMENTS, 1941-42, FALL 1943, AND ESTIMATED FOR FALL 1946

Group E - Teachers Colleges and Normal Schools

Stratum*	1941-42			Fall 1943			Fall 1946 (estimated from sample)		
	σ_x	$\bar{x}$	C.V.	σ_x	$\bar{x}$	C.V.	σ_x	$\bar{x}$	C.V.
e-1	505	1,856	.272	325	865	.376	1,271	2,200	.578
e-2	109	1,278	.085	190	515	.369	251	1,638	.153
e-3	114	866	.132	189	387	.488	278	992	.280
e-4	86	553	.156	82	251	.327	243	752	.323
e-5	130	255	.510	86	158	.544	177	399	.444

* Does not include other strata for which variances were not computed for all three periods.

[2] Originally advanced by Neyman (6). See also Snedecar (7).

Table II

ANALYSIS OF1944 ENROLLMENT STATISTICS ON BASIS OF WHICH ALLOCATION OF CASES WAS MADE AMONG SIX STRATA OF TEACHERS COLLEGES AND NORMAL SCHOOLS

Stratum *	N_i	$\bar{x}_i$	σ_i	$N_i \sigma_i$	$N_i \sigma_i^2$	n_i
(1)	(2)	(3)	(4)	(5)	(6)	(7)
e-1	13	865	325	4,225	1,373,268	9
e-2	18	515	190	3,420	649,854	7
e-3	26	387	189	4,914	930,072	10
e-4	42	252	82	3,444	285,138	7
e-5	73	159	86	6,192	533,520	13
e-6	24	163	190	4,560	867,096	10
Total	—	—	—	26,755	4,638,948	56 **

*Stratum e-6 consists of institutions with no men enrolled in 1944. Strata e-1 to e-5 inclusive were classified by size according to 1941-42 enrollments. This table does not include stratum e-8 consisting of five institutions in this class for which there were no enrollment data for 1942 or 1944. In all such strata a systematic sample of one in five was drawn.

**Does not include one institution sampled from the 5 institutions in stratum e-8.

Efficiency Gained by Stratification

At this point it is of significance to note the efficiency which results from the stratified-random design with optimum allocation as described above. The usual means of determining the efficiency of a sample is a comparison with an unrestricted random sample. If there was no stratification, that is to say, if all of the teachers colleges had been lumped together and a random sample drawn from among them with the same type of estimate as in equation (1), all teachers colleges would in effect become one single stratum and the standard error of the estimated total enrollment would be:

$$\sigma_s^2 = \frac{N^2 \sigma^2 x}{n} \left(\frac{N-n}{N-1} \right) \qquad \text{.....(8)}$$

The variance for all 184 teachers colleges, was 62,153. For this particular group of 184 teachers colleges for which there was data, the standard error using equation (8) would be approximately 5,000. A stratified-random design was geared to a standard error of 2,824. The stratified plan used in the survey, was, therefore, almost 80 per cent more efficient than the unrestricted random design would have been. The number of cases required on a random basis to produce the standard error of 2,824, which was the goal of the survey, would be so large that practically all of the 184 cases or a complete count would be required.

In other words, sampling simply would not be feasible in the type of finite universe with which we are dealing without taking advantage of some of the techniques which we utilized or others of similar merit. Sampling in a finite population is feasible where the proper types of sampling techniques are used.

To increase even further sampling reliability for each type category, additional stratification according to size and the increase or decrease in civilian population 1940-44 in the State in which the institution is located was introduced. This substratification was carried to the point where each sample case represented a distinct group of schools. Each school within each stratum was assured equal chance of selection through the use of random numbers. For this design the reliability of totals for all higher educational institutions is better than that indicated by the anticipated .05 relative error.

Further substratification was found useful in strata c-6 (colleges of arts and sciences - women only), d-7 (technical and professional schools - men only), and g-6 (privately controlled junior colleges -

women only). In each case there were substantial numbers of institutions heterogeneous as to enrollment. In each case five substrata of approximately equal enrollment were established according to 1941-42 enrollment. This further step reduced the number of cases required, n, according to equation (7) as follows:

Group c	106 to 51
Group d	114 to 67
Group g	92 to 39

Calculating Estimated Sampling Errors From the Sample Itself

The above procedures in designing the sample involved approximations of variances expected in 1946. It was, therefore, desired (a) to check the effectiveness with which these approximations served in the efficiency of the sample plan, and (b) to inform those using enrollment estimates of their reliability.

The sample was designed for estimating total enrollment. Time, resources, and detail of previous data, did not permit determining in advance what reliability the design should produce with enrollment components, such as men, women, veterans, etc. Since there is not perfect correlation between each of these and total enrollment, the coefficients of variation as designed were expected to be greater than .05. It was important to determine by how much before reporting results of the survey.[3]

The variances used in designing the sample and allocating cases were based upon complete or nearly complete enumeration of the various group universes. Estimating variances actually obtained from the sample required the usual modifications in formulae.

Equations given below, without proof, are based, with one exception, on well-known theorems.

Where σ_i^2 is the population variance, as before, and S_i^2 is the sample variance, i.e.,

$$S_i^2 = \frac{\sum_{j=1}^{n_i} (N_{ij} - \bar{x}_i)^2}{n_i}$$

in the ith stratum

$$\frac{n_i - 1}{n_i}\ \sigma_i^2 = \frac{N_i - 1}{N_i}\ E\left(s_i^2\right) \qquad \text{.....(9)}^4$$

Therefore, an unbiased estimate of the population variance $\hat{\sigma}_i^2$ may be written

$$\hat{\sigma}_i^2 = \left(\frac{N_i - 1}{N_i}\right)\left(\frac{n_i}{n_i - 1}\right) S_i^2 \qquad \text{.....(10)}$$

An unbiased estimate of the variance of an estimate for the $\frac{N_i}{n_i} \sum_{j=1}^{n_i} x_{ij}$ ith stratum would be

$$\hat{\sigma}_{s_i}^2 = \frac{N_i^2}{n_i}\left(\frac{N_i - n_i}{N - 1}\right) \hat{\sigma}_i^2 \qquad \text{.....(11)}$$

From (10) this may be written

$$\hat{\sigma}_{s_i}^2 = N_i \left(\frac{N_i - n_i}{n_i - 1}\right) S_i^2 \qquad \text{.....(12)}$$

For convenience in computation the following form was actually used:

$$\hat{\sigma}_{s_i}^2 = \frac{N_i (N_i - n_i)}{n_i (n_i - 1)} \left\{ \sum_{j=1}^{n_i} x_{ij}^2 - \left(\sum_{j=1}^{n_i} x_{ij}\right)^2 \Big/ n_i \right\} \qquad \text{.....(13)}$$

The variances of estimates over all strata in a group or a combination of groups of strata was a summation of the variances in (13) over all such strata. That is, the estimated variance $\hat{\sigma}_s^2$ of our estimate for enrollment in a given type of institution of L strata was, from (12):

$$\hat{\sigma}_s^2 = \sum_{i=1}^{L} N_i \left(\frac{N_i - n_i}{n_i - 1}\right) S_i^2 \qquad \text{.....(14)}$$

In a few cases where only one institution was sampled in a stratum, an estimate was made assuming proportionately with adjacent strata on the basis of variances computed for 1941-42 and fall 1943.

A summary of enrollment estimates and standard errors appears in table III.

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[3] A plan was anticipated of using ratio estimates if this were found necessary for some of the special groups of enrollments. These would have been slightly biased, but would have been expected to yield lower sampling variances. See reference (3). The reliabilities of estimates as outlined in the foregoing, however, were found to be acceptable.

[4] The writer is indebted to Dr. W. Edwards Deming for this identity.

Table III

SAMPLING ERRORS FOR ESTIMATES OF1946 FALL ENROLLMENT IN HIGHER EDUCATIONAL INSTITUTIONS

Type of institution	All students			Men			Women			Veterans		
	$\hat{S}$	$\hat{\sigma}_s$	C.V.	$\hat{S}$	$\hat{\sigma}_s$	C.V.	$\hat{S}$	$\hat{\sigma}_s$	C.V.	$\hat{S}$	$\hat{\sigma}_s$	C.V.
		Amount	%		Amount	%		Amount	%		Amount	%
All institutions	2,078,095	46,750	2.2	1,417,595	40,152	2.8	660,500	16,679	2.5	1,080,396	33,159	3.1
1. Universities and large institutions of complex organization	1,031,430	37,515	3.6	762,423	32,063	4.2	269,007	11,714	4.4	591,468	25,825	4.4
2. Colleges of arts and sciences	439,449	22,883	5.2	249,738	20,851	8.3	189,711	9,935	5.2	194,570	18,434	9.5
3. Independent technical and professional schools	210,176	7,067	3.4	178,409	6,134	3.4	31,767	2,917	9.2	129,238	5,396	4.2
4. Teachers colleges and normal schools	150,059	6,290	4.2	78,963	5,180	6.6	71,096	3,306	4.7	61,780	4,289	6.9
5. Junior colleges	188,139	12,276	6.5	121,069	8,848	7.3	67,070	4,486	6.7	85,124	6,456	7.6
6. Negro institutions	58,842	3,786	6.4	26,993	2,573	9.5	31,849	1,645	5.2	18,216	1,900	10.4

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